February 1, 2017

Chuck Hubert - Senior Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
200 Scotia Centre P.O. Box 938
Yellowknife, NT
X1A 2N7

Dear Mr. Hubert:

Re: Alternative Energy Concept Study

Dominion Diamond Ekati Corporation (DDEC) is pleased to provide the following Alternative Energy Concept Study. During the Jay Environmental Assessment, DDEC committed to conducting a concept study of additional potential investments in alternative energy including areas such as wind and solar energy.

> *Developer's Commitment #52:*
>
> *Dominion Diamond commits to conducting a concept study of additional potential investments in alternative energy including areas such as wind and solar energy. This study will be led by Dominion Diamond staff drawing on appropriate external expertise, with a summary of results to be made publicly available within one year of the Mackenzie Valley Environmental Impact Review Board's Report of Environmental Assessment.*

DDEC recognizes that reliance on a single energy source such as diesel increases environmental, social and business risks. DDEC is particularly aware of these risks given recent announcements on carbon pricing and the corresponding need to reduce emissions, now and into the future. This study was led by DDEC staff and DDEC commissioned SysEne Consulting Inc. for external expertise in Alternative Energy systems approach evaluation.

This concept level study assumes that the Jay Project is advanced extending the Ekati mine's current Life of Mine plan past 2023.

The alternative energy options were determined by first reviewing all commercially available energy technology options and then determining a conceptual "most likely" case for each technology that could fit the site requirements. The options studied include:

DOMINION DIAMOND EKATI CORPORATION
1102, 4920-52nd Street, Yellowknife, Canada X1A 3T1 T 1.867.669.6100 F 1.867.669.9293 www.ddcorp.ca

No.	Alternative Energy Option
1	Wind (-diesel hybrid) low penetration (~10%)
2	Small scale solar for off-grid applications
3	Biodiesel, up to 5 million litres B100
4	Wood pellet heating
5	Solar PV grid-connected 100 kW class
6	LNG, 11% of total Ekati diesel for powerhouse
7	Hydroelectric (1-10 MW), small hydro or run-of-river
8	Geothermal electricity

For this study, opportunities recommended for further evaluation were assessed with consideration to the Jay Project extending the life of the mine, technical feasibility, overall economics, overall risk, environmental performance, social benefits, and other conditions.

Wind power generation is promising if a new installation can be matched to the life of mine of Ekati, or if the existing installation at Diavik could be accessed technically and commercially, and is therefore recommended for more detailed economic and technical studies. Small-scale solar for off-grid applications is also promising, especially for remote outbuildings and in a reclamation context. Biodiesel and wood pellet heating could be interesting in the future, depending on the cost of diesel, regional supply strategy, and available incentives. At this time, the other options are not plausible to pursue due to challenges associated with:

- economics,
- proximity to resources (e.g. hydroelectric or geothermal),
- life of the alternative energy project vs. life of mine, or
- lack of an all-season road.

If you have any questions or concerns regarding this study, please contact me at 867-669-6116 or Claudine.Lee@Ekati.DDCORP.CA.

Sincerely,

Claudine Lee

Claudine Lee, M.Sc., P.Geol.
Head – Environment and Communities

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ALTERNATIVE ENERGY CONCEPT STUDY

JAY PROJECT

Prepared in partnership between Dominion Diamond Ekati Corp. and SysEne Consulting Inc.

Dominion Diamond Ekati Corp.	SysEne Consulting Inc.
Claudine Lee, M.Sc., P.Geol.	Flyn McCarthy, P.Eng.
Mohit Varshney, EIT, PMP	Craig Louie, P.Eng.
Elliot Holland, BSE, MBA	Michael Eiche, P.Eng.
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	Scott Stanners, PhD
	Chris Norman, P.Eng.

Revision: 0

February 2017

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Abbreviations

B100, B5, B20	Biodiesel blends. B100 = 100% biodiesel. B5 = 5% biodiesel / 95% diesel, etc.
CapEx	Capital Expenditure
DDEC	Dominion Diamond Ekati Corporation
kW	kilowatt
LNG	Liquefied Natural Gas
GhG	Greenhouse gas
MW	Megawatt
NWT	North West Territories
OpEx	Operating Expenditure
PV	Photovoltaic

1 EXECUTIVE SUMMARY

The Ekati Diamond Mine is located in the sub-Arctic tundra, 100 km above the treeline, 310 km northeast of Yellowknife, and 200 km south of the Arctic Ocean. The Jay kimberlite pipe (Jay pipe) is located beneath Lac du Sauvage in the southeastern portion of the Ekati claim block, approximately 25 km from the main facilities and approximately 7 km to the northeast of the Misery Pit. Many of the facilities required to support the development of the Jay pipe and to process the kimberlite currently exist at the Ekati mine. The Jay Project will be an extension of the Ekati mine, increasing the life of mine to 2034. The Jay pipe was subjected to a full Environmental Assessment (EA) conducted by the Mackenzie Valley Environmental Impact Review Board (MVEIRB), which was completed in February of 2016.

The MVEIRB recommended approval of the Jay Project subject to implementation of various measures as described in the *Jay Report of Environmental Assessment and Reasons for Decision* (REA). On May 19, 2016, the Government of the Northwest Territories Minister of Lands recommended under sub-paragraph 130(1)(b)(i) of the *Mackenzie Valley Resource Management Act* (MVRMA) that the responsible ministers adopt the recommendation of the MVEIRB, which was that the development be approved subject to the implementation of the measures and developer's commitments as described in the REA.

Dominion Diamond Ekati Corporation (DDEC) recognizes that reliance on a single energy source such as diesel increases environmental, social and business risks. DDEC is particularly aware of these risks given recent announcements on carbon pricing and the corresponding need to reduce emissions, now and into the future. During the Jay Environmental Assessment, DDEC committed to conducting a concept study of additional potential investments in alternative energy including areas such as wind and solar energy (Developer's commitment #52). This study was led by DDEC staff and DDEC commissioned SysEne Consulting Inc. for external expertise in Alternative Energy systems approach evaluation.

This concept level study assumes that the Jay Project is advanced extending the Ekati mine's current Life of Mine plan past 2023.

1.1 The Jay Project

The Jay Project (Project) consists of mining and processing diamonds from the Jay Pit, in Lac du Sauvage. Trucks will transport ore along a road from the Jay Pit to the Misery site and then to the Ekati mine site for processing.

The Project plans to use existing infrastructure at the Ekati mine, including mined out pits, processing facilities and camps, the Misery haul road, airport, powerhouse, and wastewater and processed kimberlite containment facilities. New infrastructure includes the Jay Pit within a new dike, some new facilities at Jay, and a new road between Misery and Jay.

1.2 Current and future energy supply requirements

The Ekati mine powerhouse currently has seven 4.4 megawatt (MW) diesel generators for a total installed capacity of 30.8 MW. Waste heat from the powerhouse is recovered by means of glycol heat exchangers to heat buildings and process water. A powerline connects the Ekati mine powerhouse to the Misery camp, and a powerline between the Misery camp and the Jay site is planned.

The Jay Project at the Jay Pit area will require approximately 3 MW of power during construction and 2 MW during open pit operations. The total power requirement for the Project, including the Ekati operations, will be on the order of 16-20 MW on average and the Ekati powerhouse has the capacity to provide power for the complete Jay Project.

Similar to the current operations, the Ekati mine and Jay Project will require a total of 60-80 million litres of diesel per year for motive, heating, power generation, and other uses.

1.3 Opportunity assessment

This study is a concept level assessment of the opportunities and risks of alternative energy options for the Jay Project. The Project lengthens the Ekati mine life, providing additional time to amortize investments in alternative energy supply. Compared to the baseline (diesel powered energy supply), alternative energy sources typically have:

- improved environmental and social benefits,
- higher capital expenditure and lower operational expenses,
- higher risk profiles.

Additionally, the conditions at the Ekati mine are unlike the traditional locations where alternative energy is applied; these northern climates are more difficult. The northern location presents both beneficial and challenging conditions for the use of alternative energy sources, including:

- reasonably good wind resources,
- higher cost power associated with diesel generation makes alternatives more attractive,
- lack of an all-season road for transporting alternative energy fuels, which makes LNG or biomass more expensive,
- extreme cold weather conditions,
- lack of sunlight in the winter, and
- less of an established supply chain.

The ice road connecting the Ekati mine site to Yellowknife is an additional constraint and risk factor for transporting diesel or alternative energy sources, and any scenario that requires additional trucks will be challenging.

For this study, opportunities recommended for further evaluation were assessed with consideration to the Jay Project extending the life of the mine, technical feasibility, overall economics, overall risk, environmental performance, social benefits, and other conditions.

1.4 Methods and analysis

The study examines the addition of electric power, fuels, and heat alternative energy supplies to the Ekati mine in consideration of the Jay Project expansion. The study evaluates alternative energy in the context of supply chains, transport logistics and operability.

The primary assessment categories are:

- technical viability
- economic impacts
- environmental performance

- social benefits
- cost of energy
- installation cost

Further consideration sub-categories include:

- energy penetration
- payback
- abundance
- difficulty
- intermittency
- demonstrated in similar applications
- heat
- transport
- efficiency
- GhG reductions
- impact to caribou
- impact to air quality
- ease of environmental permitting
- siting
- impact to ice road
- reliability in the North
- procurement lead time

The economic assessment is done both on a capital expenditure and life-cycle cost basis to a conceptual level of accuracy.

The alternative energy options were determined by first reviewing all commercially available energy technology options and then determining a conceptual "most likely" case for each technology that could fit the site requirements. The options studied include:

No.	Alternative Energy Option
1	Wind (-diesel hybrid) low penetration (~10%)
2	Small scale solar for off-grid applications
3	Biodiesel, up to 5 million litres B100
4	Wood pellet heating, add to new Misery Camp if boiler, rather than electric heat specified
5	Solar PV grid-connected 100 kW class
6	LNG, 11% of total Ekati diesel for powerhouse
7	Hydroelectric (1-10 MW), small hydro or run-of-river
8	Geothermal electricity

1.5 Base case

The base case assumes use of the current infrastructure, such as the existing powerhouse and fuel tank farm, plus the planned additional infrastructure, such as diesel heating for the new buildings as part of the Jay Project. The diesel is trucked over the Tibbitt to Contwoyto Winter Road each winter and stored on site. The diesel costs consider current pricing, with some sensitivity analysis for different future pricing scenarios.

1.6 Summary conclusions

Wind power generation is promising if a new installation can be matched to the life of mine of Ekati, or if the existing installation at Diavik could be accessed technically and commercially, and is therefore recommended for more detailed economic and technical studies. Small-scale solar for off-grid applications is also promising, especially for remote outbuildings and in a reclamation context. Biodiesel and wood pellet heating could be interesting in the future, depending on the cost of diesel, regional supply strategy, and available incentives. At this time, the other options don't seem plausible to pursue due to challenges associated with:

- economics,
- proximity to resources (e.g. hydroelectric or geothermal),
- life of the alternative energy project vs. life of mine, or
- lack of an all-season road.

The further sections in the document go into each of the above sections in more detail.

2 PROBLEM DEFINITION

Dominion Diamond Ekati Corporation (DDEC) is planning a major expansion, Jay Project, at their Ekati mine site, potentially extending the mine life to 2034. The main reasons for studying alternative energy options are to:

- improve the environmental footprint of the project,
- improve life-cycle economics,
- reduce risks (such as diesel ice road logistics), and
- address stakeholder concerns, including commitments for the Jay Project Environmental Assessment.

Climate change is an important environmental, economic and political challenge in the NWT and is an important issue for NWT residents and Canadians in general. The federal and provincial governments have signalled the requirement for some form of carbon pricing by 2018, which could impact the Ekati mine's operational cost associated with diesel-fueled energy. The federal government's commitment to eliminate subsidies for fossil fuels by 2025 could further increase the cost of diesel-fueled energy.

Alternative energy projects are becoming increasingly feasible and competitive with conventional energy sources, and some early systems have found some success in the North. At the same time, the technical conditions at the mine site are challenging, supply chains for alternative energy systems are often less established (especially in the North), and alternative energy systems typically have higher capital expenditure requirements (though typically lower operating expenditure).

The capital expenditure for the Jay Project is large, on the order of $800 million, which makes it challenging to accommodate any alternative energy projects with high capital expenditures.

3 PROJECT BUSINESS AND TECHNICAL REQUIREMENTS

3.1 Mine description

The Ekati Diamond Mine is located in the sub-Arctic tundra, 100 km above the treeline, 310 km northeast of Yellowknife, and 200 km south of the Arctic Ocean. The Jay kimberlite pipe (Jay pipe) is located beneath Lac du Sauvage in the southeastern portion of the Ekati claim block, approximately 25 km from the main facilities and approximately 7 km to the northeast of the Misery Pit.

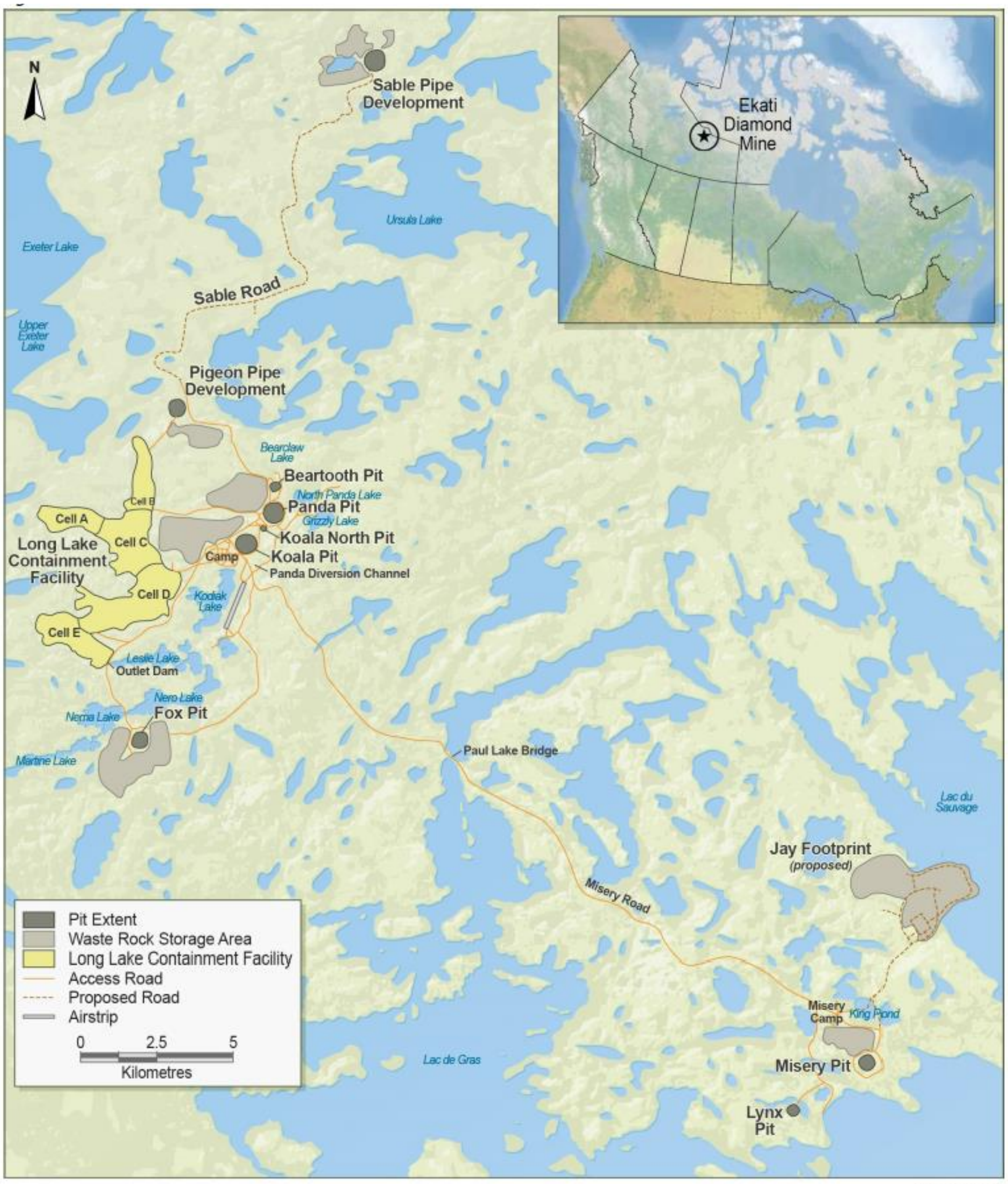


Figure 1 Ekati Mine Region Map (DDEC Report 2016)

3.2 The Jay Project

The Jay Project consists of mining and processing diamonds from the Jay Pit, in Lac du Sauvage. Trucks will transport ore along a road from the Jay Pit to the Misery site and then to the main Ekati mine site for processing.

Many of the facilities required to support the development of the Jay pipe and to process the kimberlite currently exist at the Ekati mine. The Project will be an extension of the Ekati mine, increasing the life of mine to 2033. The Jay pipe was subjected to a full Environmental Assessment (EA) conducted by the Mackenzie Valley Environmental Impact Review Board (MVEIRB), which was completed in February of 2016.

The Project plans to use existing infrastructure at the Ekati mine, including mined out pits, processing facilities and camps, the Misery haul road, airport, powerhouse, and wastewater and processed kimberlite containment facilities. New infrastructure includes the Jay Pit within a new dike, some new facilities at Jay, and a new road between Misery and Jay.

Bulk supplies are shipped between Yellowknife and the Ekati mine over the Tibbitt to Contwoyto Winter Road ("ice road") over 1-2 months each winter, including about 1400 truckloads (70 million litres) of diesel. Supply to the Ekati mine during the rest of the year is by air only.

3.3 Current and Future Energy Supply Requirements

The Ekati mine powerhouse currently has seven 4.4 megawatt (MW) diesel generators for a total installed capacity of 30.8 MW. Waste heat from the powerhouse is recovered by means of glycol heat exchangers to heat buildings and process water. A powerline connects the Ekati mine powerhouse to the Misery camp, and a powerline between the Misery camp and the Jay site is planned.

The Jay Project at the Jay Pit area will require approximately 3 MW of power during construction and 2 MW during open pit operations. The total power requirement for the Project, including the Ekati operations will be on the order of 16-20 MW on average, and the Ekati powerhouse has the capacity to provide power for the complete Jay Project.

Similar to the current operations, Ekati and Jay Project will require a total of 60-80 million litres of diesel per year for motive, heating, power generation, and other uses.

4 ASSESSMENT OF OPTIONS

4.1 Description of alternatives compared to the baseline

The alternative energy options studied include:

- Wind
- Solar
- LNG
- Bioenergy (biodiesel or wood pellets)
- Hydroelectric
- Geothermal

Small scale alternative energy options have also been included for remote ancillary operations such as pit dewatering and pit filling, seismic sensors, etc.

4.2 Methodology

4.2.1 Alternative Energy Options for Northern Operations

Alternative energy options for Northern operations come with additional complexity and more uncertainties than conventional alternatives, such as diesel gensets. Successful application of alternative energy options requires a comprehensive study of these complexities and uncertainties, especially when applied to remote northern mining operations.

The benefits of alternative energy options are lower power generation costs and lower greenhouse gas emissions in comparison with diesel-based power generation. Alternative energy supplies are typically used to offset as much of the baseload (higher cost) energy as possible. This usage is different than with conventional power generation systems, and often requires different designs of power distribution, controls architecture, and operating procedures.

4.2.2 Specific Alternative Energy Challenges

While there are successful alternative energy projects, there are also many that have had issues such as lower than expected availability, technical reliability problems, integration issues with operations, and financial underperformance. On the surface, alternative energy options look similar to conventional energy options, and the interfaces don't seem that complicated, however, rarely are these projects that straight-forward. In many projects, and especially with inexperienced operations, integration of alternative energy options presents significant challenges, including:

- electric (micro)-grid stability,
- inability to utilize the power when desired, or excess power when it is not required, and
- long payback. Renewables usually have higher capital expenditures and lower operational expenditures and therefore must match the life of mine plan and requirements.

4.2.3 Methods and analysis

This study examines the addition of alternative energy systems to the Ekati mine in conjunction with the Jay Project. The forms of energy considered are electric power, fuels, and heat. The supply chains of procuring the energy and equipment to site are evaluated.

The primary assessment categories are:

Category	Description
technical viability	available to site, practical to use, reliable at site, etc.
economic benefits	economic business case
environmental performance	impacts to GhG's, wildlife, water, land use, air quality, etc.
social benefits	economic growth and job creation, energy self sufficiency / independence, local health impacts, community, cultural, and aboriginal values, etc.
cost of energy	$/kWh or $/litre
installation cost	$/kW based on total project cost

Further consideration sub-categories include:

Category	Description
energy penetration	percent of energy used annually at site
payback	financial payback period
abundance	abundance of energy source available to the site
difficulty	difficulty to implement and integrate the energy source on site
intermittency	availability of the energy source
demonstrated	demonstrated at scale and in similar sites
heat	availability of heat for space heating (diesel generators in the powerhouse provide space heating as well as electricity)
transport	transportation logistics of energy to site
efficiency	efficiency of energy conversion from fuel to useful form (e.g. to electricity)
GhG reductions	greenhouse gas reductions
impact to caribou	impact to local caribou herd
impact to air quality	impact to local air quality
ease of environmental permitting	how easy it would likely be to get the environmental permit for the alternative energy source
siting	how feasible and practical is its siting
impact to ice road	impact to the ice road for transport logistics
reliability in the North	how reliable the alternative energy system has been in the North or similar conditions
procurement lead time	how long it would take to procure the alternative energy system from concept phase to operation

The assessment scale is defined as follows:

Technical Viability	
Description	This criterion considers: -Available to site -Practical to use -Reliable at site
High	This technology is reliable to use, integrate, or support at site
Medium	A mix of high and low characteristics
Low	Generally, the technology is difficult to use, integrate, or support at site
Economic Benefits	
Description	This criterion considers: -Economic business case
High	Resource options that are less expensive than the baseline
Medium	This technology is comparable to the baseline
Low	Resource options that are more expensive than the baseline
Environmental Performance	
Description	This criterion considers: -Impact on GhG's -Impact on wildlife -Impact on water -Impact on air quality -Impact on land use
High	This technology can make a significant improvement over the baseline
Medium	This technology has a mix of high and low characteristics
Low	This technology is no better than the baseline
Social Benefits	
Description	This criterion considers: -Economic growth and job creation -Energy self-sufficiency / independence -Local health impacts -Community, cultural, and aboriginal values
High	This technology can make a significant improvement over the baseline
Medium	This technology has a mix of high and low characteristics
Low	This technology is no better than the baseline

4.2.4 Economic assessment

The economic business case considers:

- incremental capital cost for the additional alternative energy system,
- logistics costs to site,
- operating cost (operating and maintenance costs, fuel costs),
- payback (typically alternative energy systems have higher capital costs and lower fuel costs than conventional energy systems, resulting in a longer payback),
- typical costs of capital,
- life of mine,
- energy price variability,
- carbon pricing (while the actual amount is uncertain, sensitivity analyses were done for multiple scenarios), and
- no financial incentives.

The level of accuracy of the economic analysis is to the conceptual level of accuracy.

4.3 Option Development

A baseline energy forecast of the mine was developed based on the mine plan.

Total Plant Feed (100% basis)

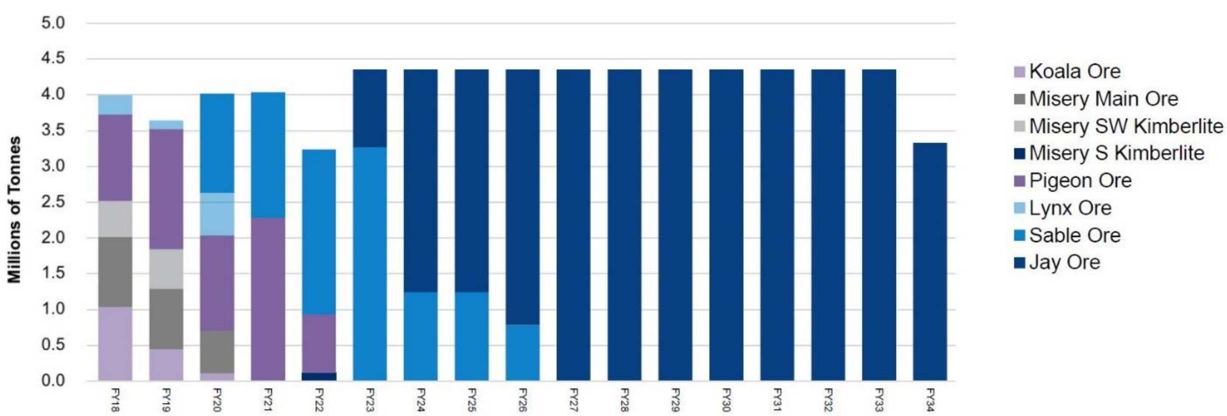


Figure 2 Ekati Life of Mine Plan (Sept. 2016 DDEC Presentation)

The baseline scenario is diesel for the powerhouse and motive equipment. All the alternative scenarios assume adding an alternative energy system to the mine to offset the use of diesel. The alternative energy options were determined by first reviewing all commercially available energy technology options and then determining a conceptual “most likely” case for each technology that could fit the site requirements.

The resulting options for assessment follow:

No.	Alternative Energy Option
1	Wind (-diesel hybrid) low penetration (~10%)
2	Small scale solar for off-grid applications
3	Biodiesel, up to 5 million litres B100
4	Wood pellet heating, add to new Misery Camp if boiler, rather than electric heat specified
5	Solar PV grid-connected 100 kW class
6	LNG, 11% of total Ekati diesel for powerhouse
7	Hydroelectric (1-10 MW), small hydro or run-of-river
8	Geothermal electricity

The assessment of each option follows in the next section.

5 OPTION ASSESSMENT

5.1 Wind

This option consists of a wind farm added to the Ekati mine and connected to the powerhouse microgrid, and then run as a hybrid system with the existing diesel generators.

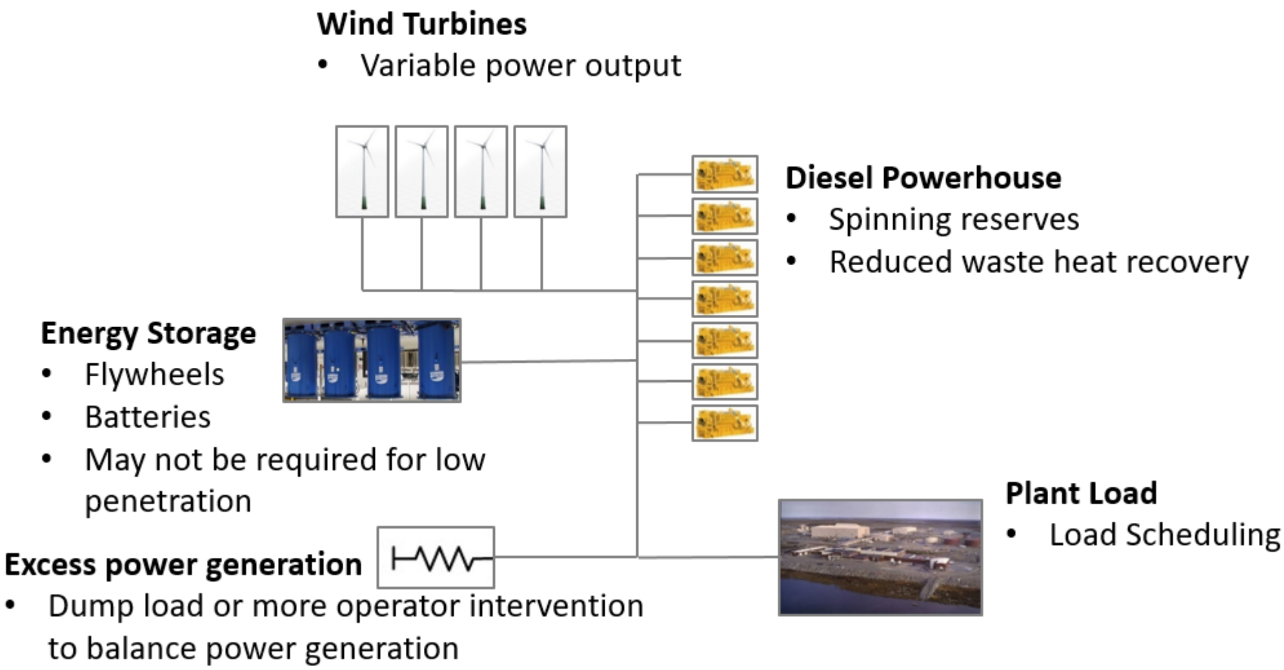


Figure 3 Wind-diesel integration at Ekati

The size of the system would be in the range of 6 to 9 MW compared with the 9.2 MW wind farm at the neighbouring Diavik mine, as the system average electrical load at the Ekati mine is lower at 16 MW, as compared to about 25 MW at Diavik.

Given the success of the Diavik wind project and the experienced gained through that investment, the initial concept investigated in this report is be similar to Diavik where the system is relatively low in energy penetration (i.e. less than 20% of the average annual energy). This simplifies the need for, or the amount of energy storage. Given the rapidly falling costs of energy storage, higher penetration systems could be investigated in future studies should they become more economic.

The neighbouring Diavik project, in which Dominion is an investor, has had good experience.

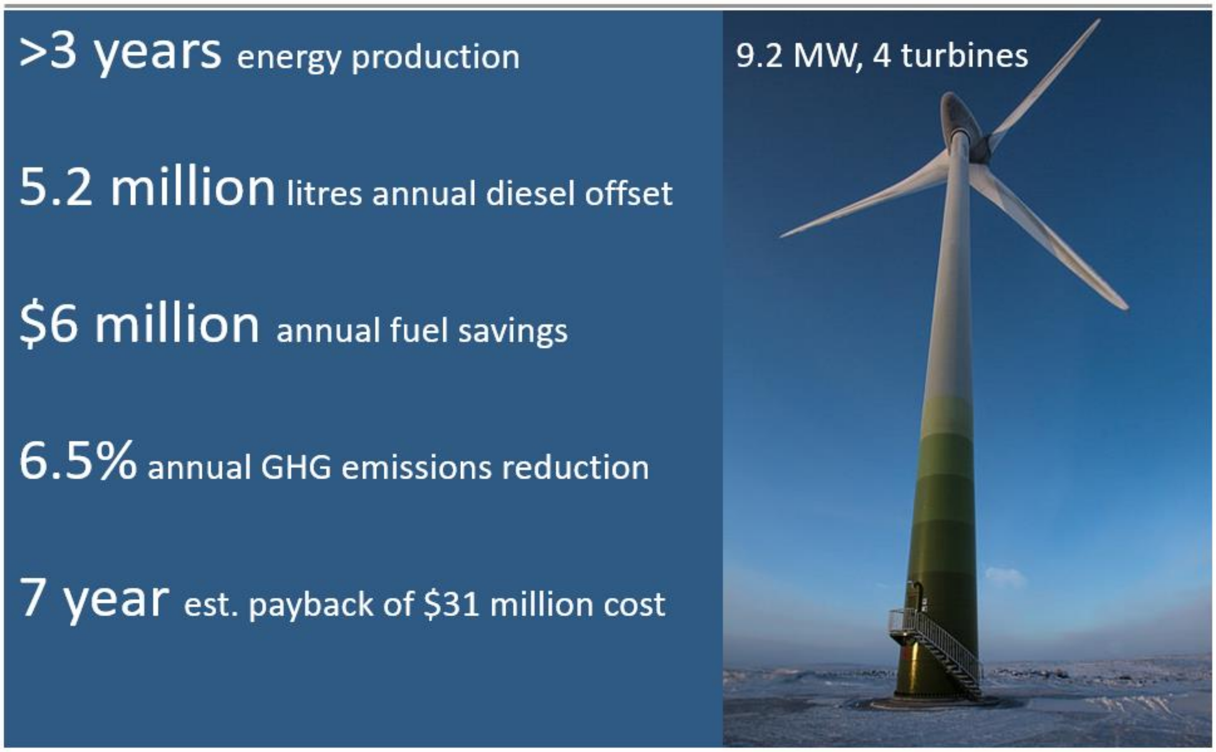


Figure 4 Diavik Wind Farm case study (Source: Diavik presentations)

It is also expected that lessons learned from the Diavik mine could be applied to the Ekati mine, such as the initial cold weather “teething issues”, or the challenges experienced around power system integration and brownouts.

The summary of the assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Wind (-diesel hybrid) low penetration (~10%)	**High** Proven technology for low penetration	**Medium** Expected to be NPV positive	**High** Meaningful GHG improvements	**High** Further develop local expertise and contractors, furthers RE use in the North	Similar to baseline and provides lower operating expenditures after 6-8 year payback	$3000-$4000/kW

Further considerations:

Option	Further Considerations: Energy Penetration	Payback	Abundance	Difficulty	Intermittency	Demonstrated
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
Wind (-diesel hybrid) low penetration (~10%)	10-20%	Simple payback in approx. <8 years	Assessments have shown Ekati is viable site for wind energy	Needs strong project champion and dedicated team	26% Capacity Factor	Highly relevant experience at Diavik

Option	Futher Considerations: Heat	Transport	Efficiency	GhG Reductions	Impact to Caribou	Impact to Air Quality
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
Wind (-diesel hybrid) low penetration (~10%)	May reduce waste heat available from diesel powerhouse	Only need to transport system to site for installation, follow Diavik example	N/A	Directly proportional to diesel offset	Siting needs impact study - learn from Diavik monitoring	**Nil** Zero polluting operating emissions

Option	Futher Considerations: Ease of Environmental Permitting	Siting	Impact on Ice Road	Reliability in the North	Procurement Lead Time
Diesel	Already done	Existing	Baseline	Baseline	Already in place
Wind (-diesel hybrid) low penetration (~10%)	Easy (assumed), follow Diavik example	Several options look feasible	May need alterations to accommodate transport of large turbine components	Demonstrated availability of 98% at Diavik after initial teething problems	1-2 years; needs early discussion with suppliers

The main issue with the concept is the challenge around the large capital cost and payback relative to life of mine. Assuming 2 years for design and permitting, 2 years for procurement, and 1 year for construction, the system would not be available at the earliest until 2022. With a ~7-year payback equivalent to the Diavik experience, this means the investment would not break even until 2029. While 2029 is beyond the mine life of Ekati without Jay, assuming Jay can be successfully permitted and economically developed, Ekati is forecast to have a mine life of 2034. This indicates that a positive return may be possible for a new wind installation. There is also some potential to reduce the timeline for a wind farm project by 1-2 years, by reducing the amount of wind data prior to procurement, though this entails additional risk.

5.1.1 Option to reuse existing wind infrastructure at Diavik

Another opportunity available regionally would be to connect the Ekati and Diavik grids, enabling the Diavik wind farm to continue to supply power after the currently projected closure of the Diavik operation in 2023. The existing grids are only 10 km apart. Two conceptual routes for a connecting transmission line are shown in Figure 5 below. The red line shows a direct line between the two sites (~10 km). This path may not be practical due to the water crossing required. The yellow line is longer (~17 km) but minimizes the water crossing distances.

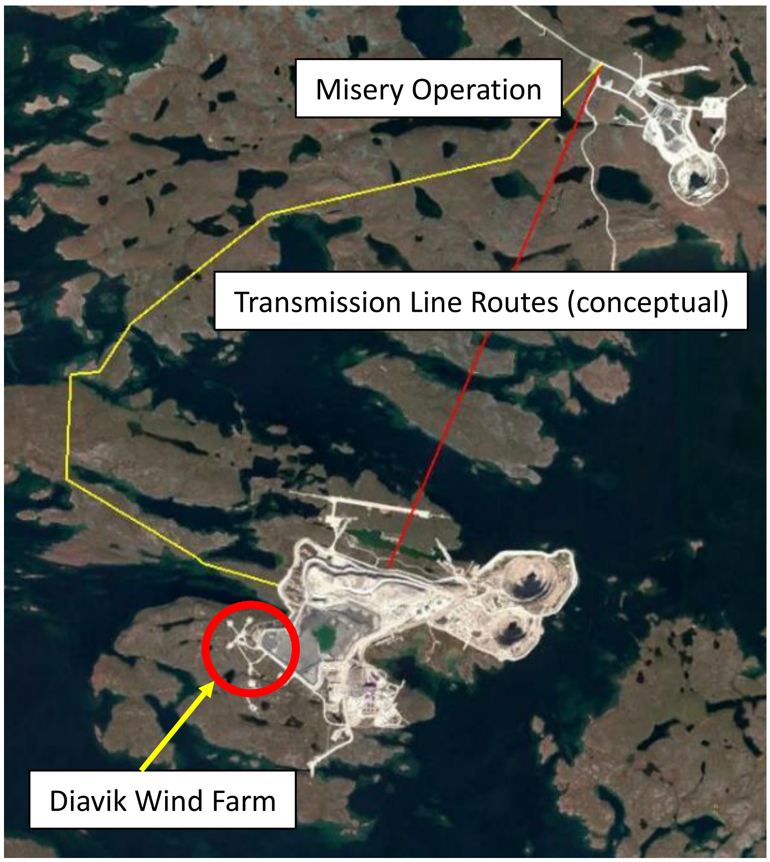


Figure 5 Transmission line between Diavik and Ekati

Using the estimated cost for transmission line construction similar projects of 1-2 million Can$/km, the range of cost estimates for just the connecting transmission line are shown in the table below:

Transmission Line	1 million Can$/km	2 million Can$/km
Red, 10 km	$10,000,000	$20,000,000
Yellow, 17 km	$17,000,000	$34,000,000

Additional costs related to the project, such as permitting, engineering studies, integration costs and costs associated with acquiring the wind farm are not included. Depending on the assumptions used, costs for just the transmission line range from $10 million to $34 million. As a benchmark, the total construction cost for the Diavik wind farm was $31 million in 2012. Key risks specific to this option include the environmental assessment, and the uncertainty around the Diavik life of mine. The operating life of wind turbines is typically 20-25 years, so this shouldn't be an issue.

Re-use of the existing wind infrastructure at Diavik could have superior economics compared to a new installation, depending upon which assumptions are used for transmission line costing. Technical challenges in construction of a transmission line and integration of the grids, as well as commercial challenges in reaching an agreement between the various stakeholders, would need to be addressed.

5.1.2 Conclusions for Wind Power Generation

Overall, it is recommended to advance into more detailed economic and technical studies of opportunities for both new and existing wind power generation.

5.2 Small scale solar for off-grid applications

Mines often have numerous ancillary operations that require intermittent or very low power requirements, for loads such as instrumentation devices, low footprint outbuildings, lighting, and small pumping loads. These smaller off-grid loads often require a continuously operating diesel generator. Using a solar array combined with battery storage presents an opportunity to power these smaller, more intermittent loads, eliminating the requirement of portable diesel gensets.

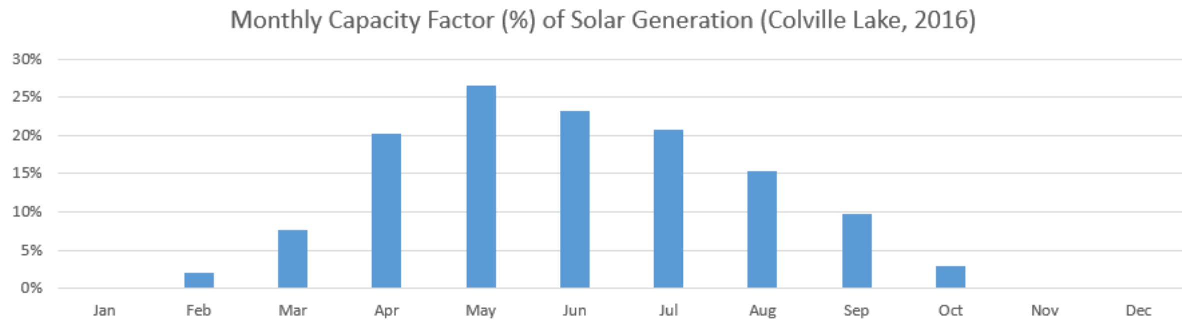
Solar installations in the medium size range, about 50-200 kW, may be advantageous in several applications. For example, they are potentially attractive in pumping situations where smaller pumping demands are required during spring runoff (highest solar radiation) for multiple years. At the Ekati mine, the near-term dewatering needs are in the 1+ MW level, but pit filling needs may be much smaller (can only take a small flow from the lake) and could be a potential opportunity. This opportunity may make sense in the future, as reclamation planning continues to advance, the de-watering/pit filling needs become better known, and solar installations continue to drop in price. If these applications can be sufficiently advanced, they could substantially reduce reclamation costs, and potentially lower reclamation security requirements.

500 GPM at 200 ft head
~20-35 kW
for continuous pumping

Figure 6 Pumping at a mine site

These pumping loads often coincide with the snow and ice melt (Spring) and therefore also coincide with the seasonal variation in solar generation. Intermittent pumping may be suitable for a solar photovoltaic system as the pumping load stability is not as critical as other loads. One may view the reservoir as analogous to energy storage here, as the pit doesn't need to be filled when there is no sunlight and the pumps work to move water to it when the sun shines.

A comparison of the solar capacity in the North with dewatering at a Northern mine (Jericho) follows:



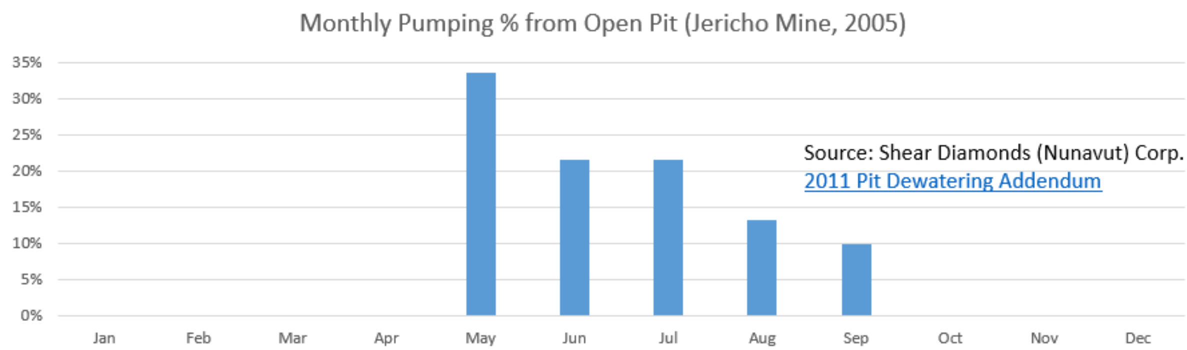


Figure 7 Pumping case study compared with solar capacity

In addition, the wide variety of Ekati outbuildings, each of which have different peak load, seasonality, reliability, and accessibility requirements, should be studied to determine which are most suited to small-scale off-grid solar installations.

The summary of the assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Small scale solar for off-grid applications	**Medium** Depends on a good match between mining load profile and solar generating profile	**Medium** Expected to be NPV positive in certain cases. Could reduce reclamation liability if accepted alternative to diesel	**High** Zero operational emissions, no noise	**High** No supply chain, no noise, O&M jobs within local community's capacity	Not fully assessed. Solar may be competitive with long term needs and mobile diesel	Not fully assessed. Solar may be competitive with long term needs and mobile diesel

Further considerations:

	Further Considerations					
Option	**Energy Penetration**	**Payback**	**Abundance**	**Difficulty**	**Intermittency**	**Demonstrated**
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
Small scale solar for off-grid applications	Not fully assessed. Solar may be competitive with long term needs and mobile diesel	Not fully assessed. Solar may be competitive with long term needs and mobile diesel	Solar power available so long as the sun is shining	Standard and reliable	From clouds and shadows	Over 20 systems installed in NWT ranging from 0.5kW to 135kW

	Futher Considerations					
Option	**Heat**	**Transport**	**Efficiency**	**GhG Reductions**	**Impact to Caribou**	**Impact to Air Quality**
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
Small scale solar for off-grid applications	No need for heat	Only need to transport system to site for installation	N/A	100% for every kWh of Diesel that is offset	Silent operation, but large footprint	**Nil** Zero polluting operating emissions

Option	Futher Considerations				
	Ease of Environmental Permitting	Siting	Impact on Ice Road	Reliability in the North	Procurement Lead Time
Diesel	Already done	Existing	Baseline	Baseline	Already in place
Small scale solar for off-grid applications	Easy	South-facing large area	**Nil** No supply chain	Proven in North and in Europe	Available commercially

Overall, small-scale solar for off-grid applications is recommended to be advanced to more detailed economic and technical studies.

5.3 Biodiesel

Biodiesel has the same energy density as diesel, which has the advantage that additional trucks on the ice road are not required. In general, using a blend of B5 to B20 (20% biodiesel, 80% diesel) does not change engine performance or life. There are significant GhG reductions between diesel and B100:

Diesel GHG g/CO2e/MJ	Biodiesel from Canola GHG g/CO2e/MJ	% Reduction
94.7	20.4	-79%

Biodiesel has been piloted successfully in select equipment at the Ekati mine, through the onsite mixture of 100% biodiesel (B100) with regular diesel to make a B10 or B20 for use in mobile equipment during the summer months. Further usage expansion up to 5 million litres per year is technically possible for haul trucks, or potentially the powerhouse.

The summary assessment follows:

Option	Summary					
	Technical Viability	Economic Benefits	Environmental Performance	Social Benefits	Cost of Energy $/kWh or $/litre	Installation Cost $/kW
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Biodiesel, up to 5 million liters B100	**Medium** Supply chain for cold weather diesel in North	**Low** Biodiesel is about 25% more expensive than today's diesel	**High** Meaningful GHG and air quality improvements	**Medium** Imported fuel.	About 25% more expensive than diesel per litre. Carbon tax of $50/tonne provides $0.10 benefit.	Minimal infrastructure upgrades

Further considerations:

Option	Further Considerations					
	Energy Penetration	Payback	Abundance	Difficulty	Intermittency	Demonstrated
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
Biodiesel, up to 5 million liters B100	Could go as high as 5 million liters of B100	Currently negative, even with Carbon pricing. Need Government Policy Support	Available and practical in small quantities. Large quanties require policy support	Good proof of application. Main issue is large quantity of cold weather, economic B100	Prefer to use in summer, though has been proven in cold weather with right formulation	Good experience at Ekati and other cold weather places

Option	Futher Considerations					
	Heat	Transport	Efficiency	GhG Reductions	Impact to Caribou	Impact to Air Quality
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
Biodiesel, up to 5 million liters B100	Can be used for motive, heating, and power as B10-B20 with no issues	Same energy density as diesel. Can practically ship.	Same as diesel	79% reduction per liter of B100	No additional impact	Meaningful improved air quality as biodiesel burns more cleanly

Option	Futher Considerations				
	Ease of Environmental Permitting	Siting	Impact on Ice Road	Reliability in the North	Procurement Lead Time
Diesel	Already done	Existing	Baseline	Baseline	Already in place
Biodiesel, up to 5 million liters B100	Easy (probably none required)	Can site additional storage tanks easily. Storage is simple.	No additional impact	Reasonable confidence, though it would be good to continue to get futher experience	Available commercially

The main issues with regular usage are:

- biodiesel is approximately 25% more expensive than regular diesel,
- blends of biodiesel above B5 present cold weather operating challenges including gelling and filter plugging; a standardized “winter blend” supply would be helpful, and
- there is a limited supply chain to the North.

Biodiesel is much more prevalent in the US because of their consumption mandates and incentive systems. In Canada, even with a future carbon tax of $50/tonne, biodiesel would still be more costly than diesel as the carbon tax only makes a difference of $0.10/litre. Long-term increases to carbon pricing beyond $50/tonne, potentially combined reductions in certain fossil fuel subsidies, could narrow the cost difference.

An example of biodiesel formulations with cold flow properties follows:

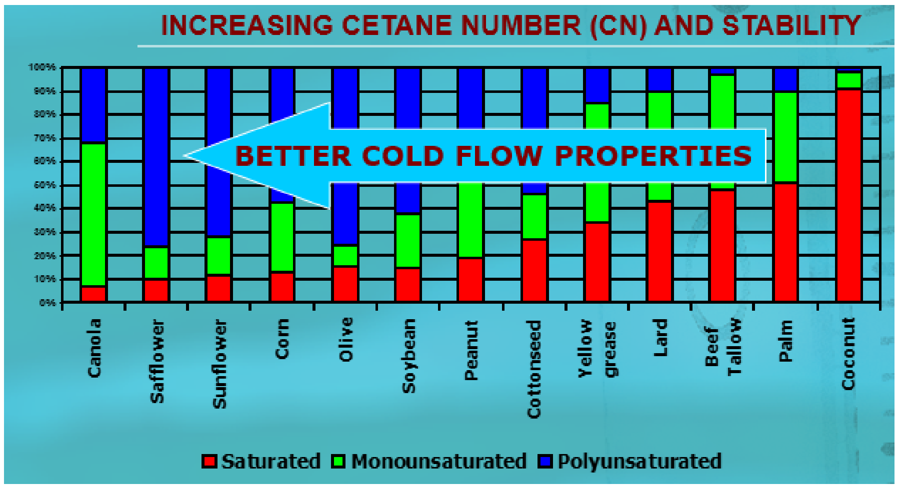
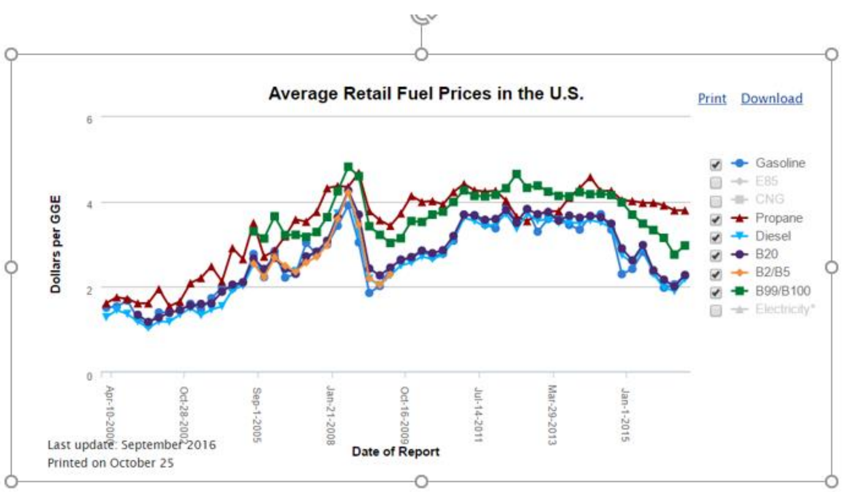


Figure 8 Different biodiesel formulations have different cold flow properties (biodiesel.org)

Biodiesel tends to be more expensive than diesel and tends to follow the diesel price trends.



July 2016
Biodiesel B100 is 23% more expensive than Diesel in US

National Average Price Between July 1 and July 15, 2016	
Fuel	**Price**
Biodiesel (B20)	$2.54/gallon
Biodiesel (B99-B100)	$3.03/gallon
Electricity	$0.12/kWh
Ethanol (E85)	$1.99/gallon
Natural Gas (CNG)	$2.05/GGE
Liquefied Natural Gas	$2.41/DGE
Propane	$2.76/gallon
Gasoline	$2.26/gallon
Diesel	$2.46/gallon

Source: Alternative Fuel Price Report, July 2016 and U.S. Energy Information Administration

Figure 9 Typical fuel prices (US)

Larger scale use of biodiesel should be considered in future when it achieves price parity either from industry economies of scale, regulatory support, carbon taxation, or renewable incentive programs. Additionally, a robust Northern supply chain is also required.

5.4 Wood pellet heating

Wood pellet boilers for space heating are prevalent in Yellowknife both in residential and commercial buildings, allowing for approximately a 30-50% reduction in heating bills over heating oil.

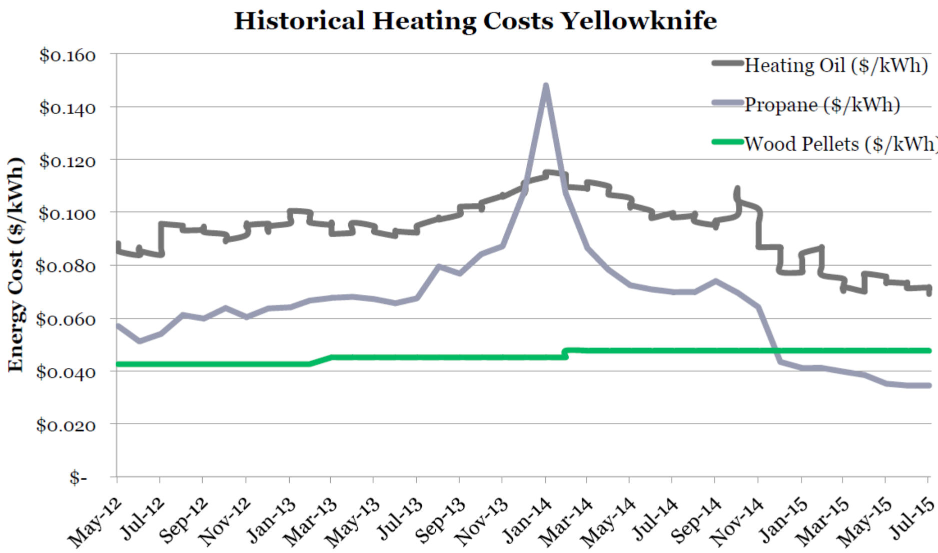


Figure 10 Historical heating costs Yellowknife (GNWT presentation, 2015)

The Ekati mine uses a significant amount of diesel for space heating. The Jay Project includes a Jay construction camp, where adding a wood pellet boiler could be technically feasible. However, electrical heating is the standard specification of most construction camps, due to the reduced installation labour, which allows for quicker and lower cost assembly. This is especially true for the many camps currently available on the used market due to the downturn in commodity prices. Requiring boiler-fired heating for a construction camp would significantly limit the procurement choices for the structure.

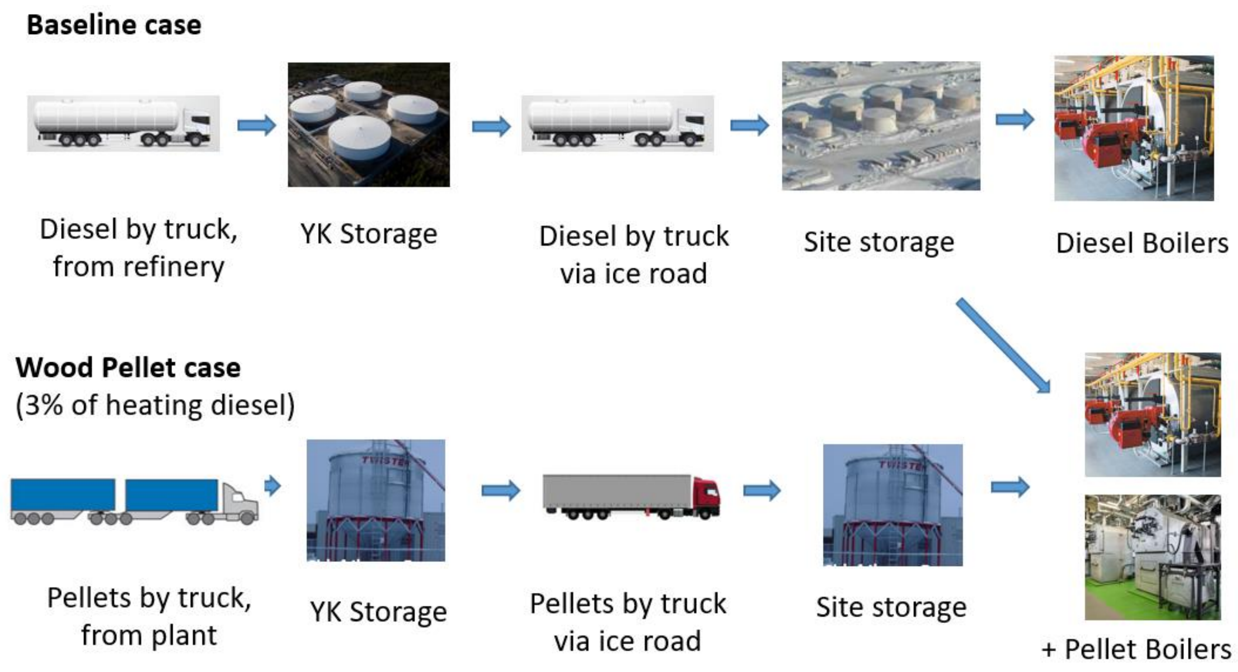


Figure 11 Wood Pellet Option

The main issue with wood pellets for the Ekati mine are:

- wood pellets have only 1/3 the energy density of diesel, requiring three times more trucks for the same amount of energy therefore increasing the number of trucks over the ice road which would be difficult given the current ice road constraints,
- the additional trucking of wood pellets over the ice road adds significantly to the overall fuel cost, and largely consumes the savings between wood pellets and diesel, and
- replacing one of the main boilers in the Ekati camp would require a very large wood pellet system (i.e. 7 MW), which would be expensive and require a large amount of wood pellet storage. It would be difficult to make an overall business case for this concept.

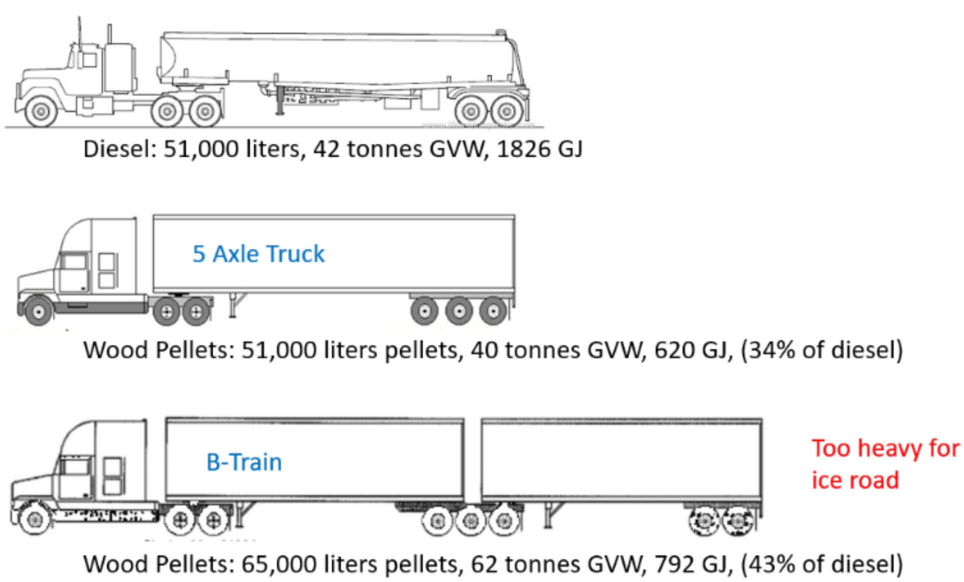


Figure 12 Wood Pellet Energy Content

The summary assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Wood Pellet Heating, add to new Misery Camp if boiler, rather than electric heat specified	**Medium** More trucks on ice road	**Low** No savings because of high transport costs over ice road	**High** Meaningful GHG improvements	**Medium** Imported fuel. Some additional employment	Breakeven at Diesel $1.04/liter	$1200/kW (thermal). Add to new Misery camp

Further considerations:

	Further Considerations					
Option	**Energy Penetration**	**Payback**	**Abundance**	**Difficulty**	**Intermittency**	**Demonstrated**
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
Wood Pellet Heating, add to new Misery Camp if boiler, rather than electric heat specified	7% of Diesel Heating, 0.7 million liters equivalent	Breakeven at Diesel $1.04/liter	Abundant Pellet supply in North Alberta	Boilers work. Main issue is more trucks on ice road	Can use year round	Over 100 commercial systems in NWT

	Futher Considerations					
Option	**Heat**	**Transport**	**Efficiency**	**GhG Reductions**	**Impact to Caribou**	**Impact to Air Quality**
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
Wood Pellet Heating, add to new Misery Camp if boiler, rather than electric heat specified	All for building heat	13 additional 5 axle trucks	Same as burning diesel	Meaningful reductions	More trucks on ice road	Cleaner burning than diesel

	Futher Considerations				
Option	**Ease of Environmental Permitting**	**Siting**	**Impact on Ice Road**	**Reliability in the North**	**Procurement Lead Time**
Diesel	Already done	Existing	Baseline	Baseline	Already in place
Wood Pellet Heating, add to new Misery Camp if boiler, rather than electric heat specified	More trucks on ice road	Can site or convert existing storage. Storage is simple	More trucks on ice road	Proven in North and in Europe	Available commercially

A modest amount of wood pellets and a smaller boiler, ~1 MW, could be a feasible option for future consideration, especially if the current winter road were replaced with an all-season access road, reducing transportation costs and storage requirements.

5.5 Solar PV grid-connected 100 kW class

PV potential in the North is not nearly as different as might be expected:

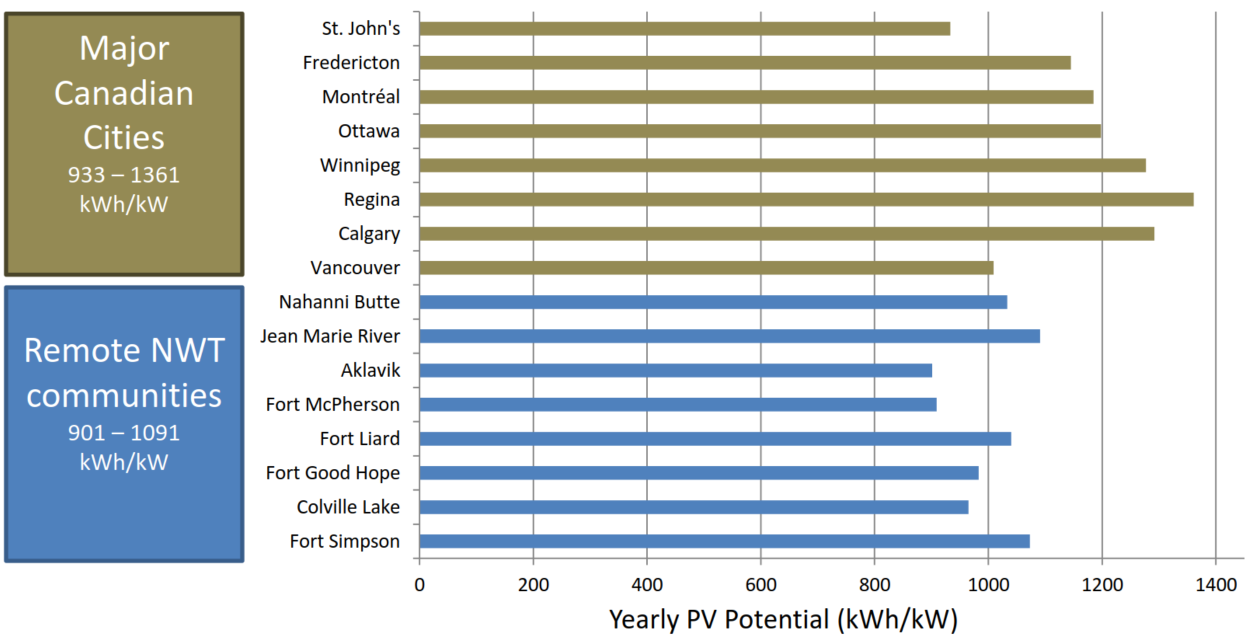


Figure 13 Solar PV Potential. Source NRCan presentation 2015.

Solar PV (photovoltaic) is currently being used in more than 20 installations in the NWT, up to the 100 kW class, including at Colville Lake, Lutsel K'e, and Fort Simpson.

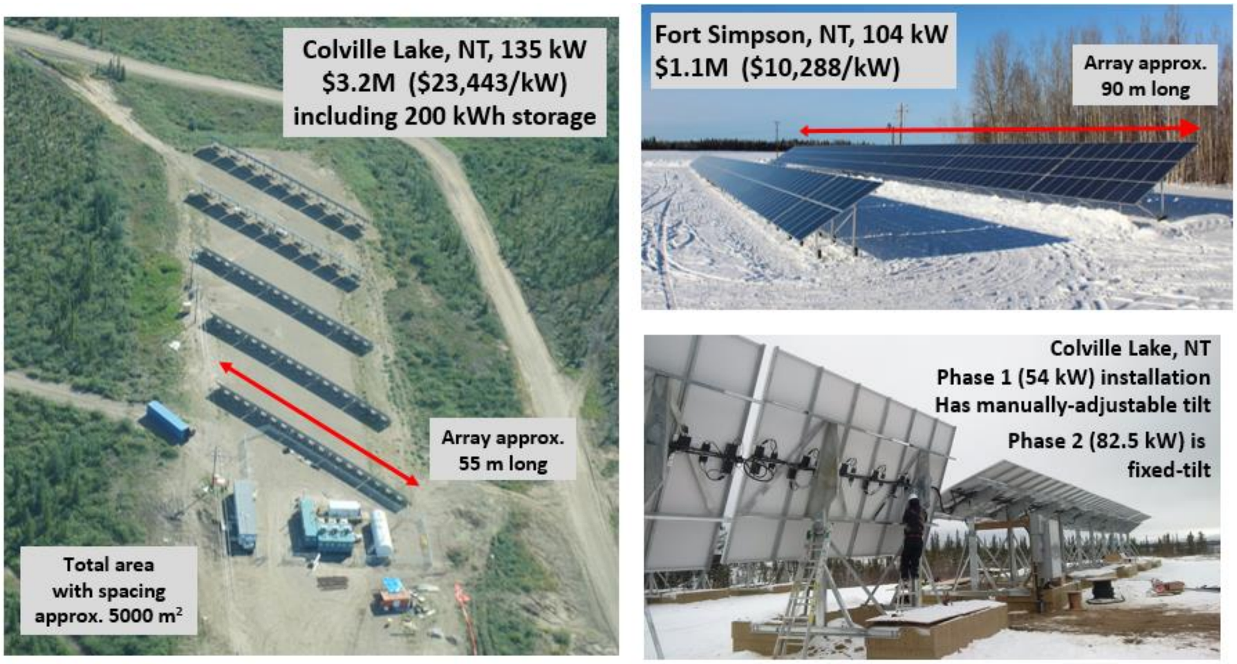


Figure 14 Northern Solar PV Installations

The Ekati mine's microgrid supplies 16 MW, on average, hence it has the capacity to add on the order of 100 kW solar generation to the grid without complex controls or energy storage, as the flexibility in the diesel powerhouse can handle the intermittence of this amount of solar generation. Much larger systems (i.e. 500 kW+) would be capital cost prohibitive. Solar PV can help reduce diesel consumption, is relatively easy to maintain and offers a consistent, "free" fuel.

A concept layout of a 100 kW solar PV installation at the Ekati mine follows:

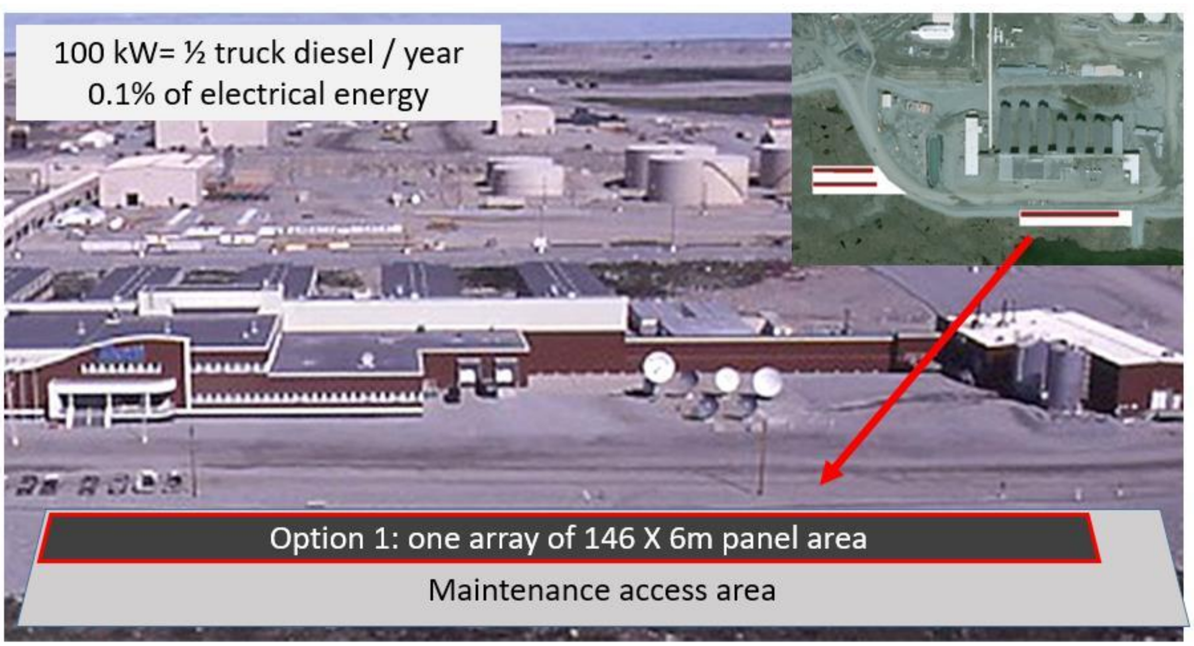


Figure 15 Solar PV 100 kW concept at Ekati

The summary assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Solar, 100 kW+ class, connected to Ekati microgrid	**High** Universally viable	**Low** CapEx high (very low OpEx)	**High** Zero operational emissions, no noise	**High** No supply chain, no noise, O&M jobs within local community's capacity	3 times more expensive than electricity from diesel. Includes amortization of capital.	$10,000/kW

Further considerations:

	Further Considerations					
Option	**Energy Penetration**	**Payback**	**Abundance**	**Difficulty**	**Intermittency**	**Demonstrated**
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
Solar, 100 kW+ class, connected to Ekati microgrid	0.1% - 1% note that large plant would require large area	Negative	Solar power available so long as the sun is shining	Standard and reliable	From clouds and shadows	Over 20 systems installed in NWT ranging from 0.5kW to 135kW

	Futher Considerations					
Option	**Heat**	**Transport**	**Efficiency**	**GhG Reductions**	**Impact to Caribou**	**Impact to Air Quality**
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
Solar, 100 kW+ class, connected to Ekati microgrid	No heat available from solar PV	Only need to transport system to site for installation	N/A	100% for every kWh of Diesel that is offset	Silent operation, but large footprint	**Nil** Zero polluting operating emissions

Option	Futher Considerations				
	Ease of Environmental Permitting	Siting	Impact on Ice Road	Reliability in the North	Procurement Lead Time
Diesel	Already done	Existing	Baseline	Baseline	Already in place
Solar, 100 kW+ class, connected to Ekati microgrid	Easy	South-facing large area	**Nil** No supply chain	Proven in North and in Europe	Available commercially

The main issues with grid-connected Solar PV for the Ekati mine are:

- the capital cost of Solar PV in the North is higher than in the South because of the more extreme environment and higher transportation and installation costs,
- the solar power generation (PV potential) in the North is good around the spring equinox at about 1,000 kWh/kW per year, however this is still lower than in the South (i.e. California) where solar PV is approximately 2,500 kWh/kW per year,
- the estimated levelized cost of electricity for solar PV is about three times higher than electricity from diesel, and
- compared to community-based installations, which can have a design life of decades, mines have a finite resource base and therefore a limited life, reducing the guaranteed lifespan of the system and further increasing the levelized cost of electricity.

Overall, the economics and resulting high levelized cost of electricity, together with the low penetration attainable for this type of installation (also considering available area) rule out the application of grid-connected solar PV for the Ekati mine given current costs. Further assessment of this option is, therefore, not recommended at this time. Solar technology does continue to be an area of rapid innovation, and this conclusion should be revisited if there are substantial and demonstrated economic improvements by others in comparable conditions.

5.6 LNG

LNG (liquefied natural gas) has been used successfully in Inuvik and at the Stornoway Renard Mine in Quebec as a lower cost option than diesel. However, both of those sites have all-season roads, and thus can receive regular (daily) deliveries, which allows them to utilize a small LNG storage system on-site.

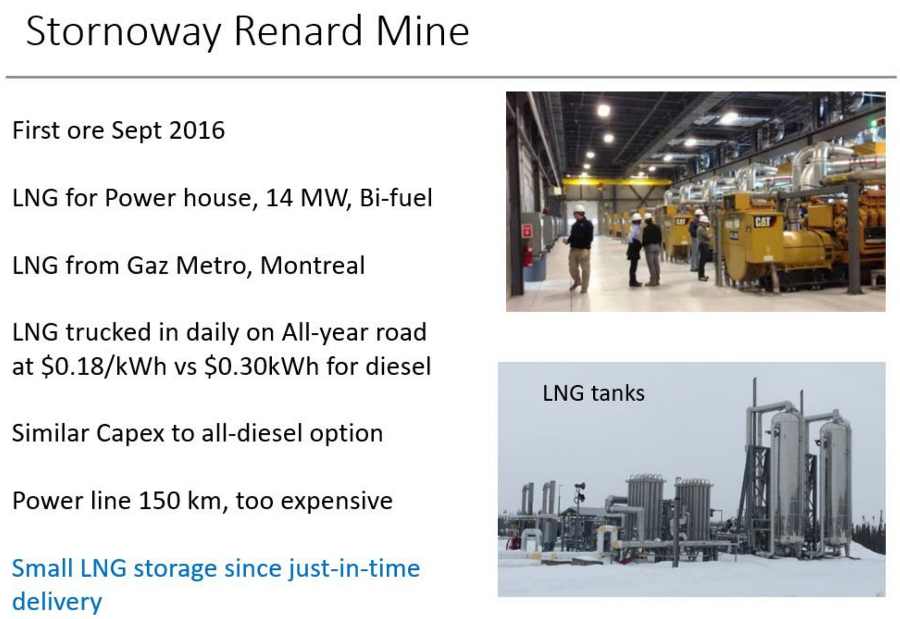


Figure 16 Stornoway Renard Mine Case Study (Quebec)

LNG could be used at the Ekati mine, in the powerhouse, using bi-fuel kits on the diesel generators, and in haul trucks.

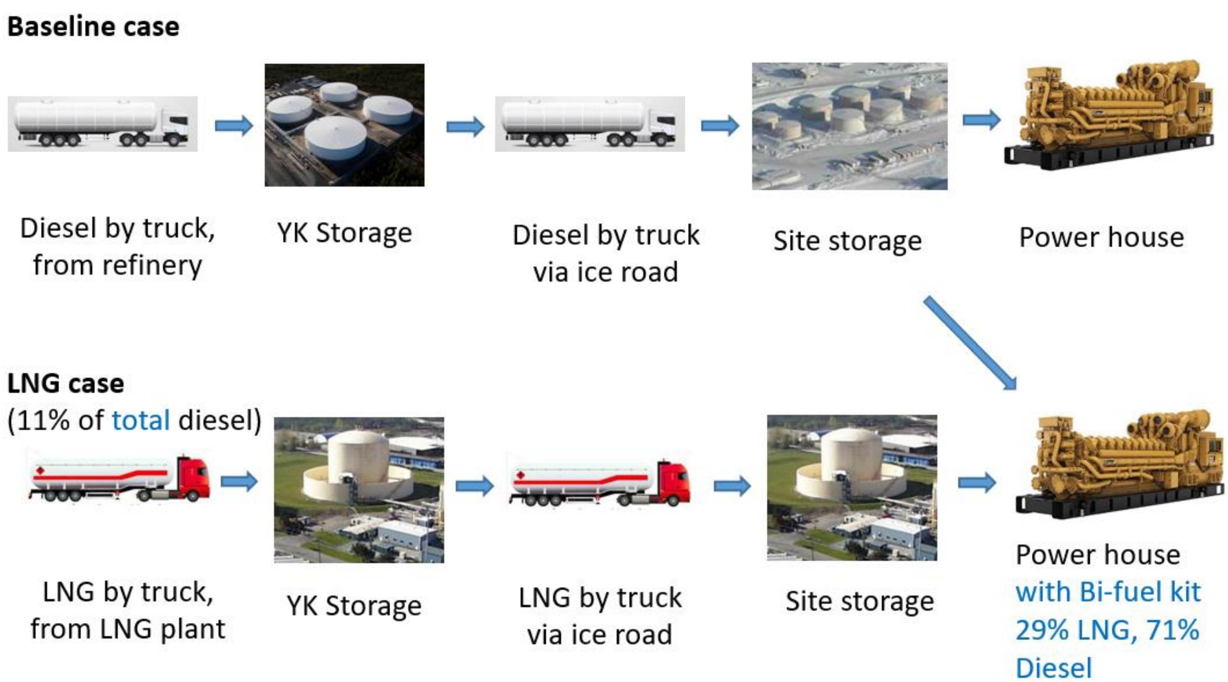


Figure 17 LNG Option at Ekati

The main issue with LNG at the Ekati mine is that there is currently no all-season road to site from the South, and this necessitates a large amount of storage at each end of the ice road (at the Ekati mine and in Yellowknife). For a system that would provide 11% of the Ekati mine's diesel consumption, LNG infrastructure in excess of $100 million would be required.

Examples of similarly sized LNG tanks follow.

Mt Hayes, Vancouver Island, Fortis BC

- 40,000 m^3 LNG Storage
- Equivalent to 25,000,000 liters of diesel
- Peak Shaving Facility
- $200 million facility

Tilbury, Delta, Fortis BC

- 16,000 m^3 LNG Storage
- Equivalent to 10,000,000 liters of diesel
- Peak Shaving and Supply Facility
- 1971 facility shown
- Tilbury 2 expansion (2016) of additional 27,000 m^3 LNG Storage for $400 million

Figure 18 LNG Storage Facility Examples

The summary assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
LNG, 11% of Total Ekati Diesel for power house	**Medium** Complex storage and supply chain	**Low** Capex too high, negative payback	**Medium** Small GHG Savings	**Low** Local concerns with emissions, fracking & safety	2 times more expensive than electricity from diesel. Includes amortization of capital.	$100 million Capex LNG Storage, Trucks and Bi-Fuel Kits. Use existing generators

Further considerations:

	Further Considerations					
Option	**Energy Penetration**	**Payback**	**Abundance**	**Difficulty**	**Intermittency**	**Demonstrated**
Diesel	100%	N/A	Imported, ice road restrictions	Standard and reliable	Flexible	Widely
LNG, 11% of Total Ekati Diesel for power house	12% of Ekati Diesel (meaningful)	Negative	Long trucking distances.	Bi-fuel kits work. More trucks on ice road. Storage is complex and costly	Can use year round	LNG is widely used in bi-fuel diesel gen sets worldwide with good performance

	Futher Considerations					
Option	**Heat**	**Transport**	**Efficiency**	**GhG Reductions**	**Impact to Caribou**	**Impact to Air Quality**
Diesel	Some waste heat	Baseline. High energy density per truck. Ice roads	Baseline	Baseline	Baseline	Baseline
LNG, 11% of Total Ekati Diesel for power house	Same heat as diesel gen sets	101 additional 5 axle trucks	Same as burning diesel	Minimal reductions	More trucks on ice road	Cleaner burning than diesel

	Futher Considerations				
Option	**Ease of Environmental Permitting**	**Siting**	**Impact on Ice Road**	**Reliability in the North**	**Procurement Lead Time**
Diesel	Already done	Existing	Baseline	Baseline	Already in place
LNG, 11% of Total Ekati Diesel for power house	More trucks on ice road. Additional complex storage at site and YK	Complex storage site with additional requirements because new technology	More trucks on ice road	Proven in North and worldwide	Storage tanks and trucks, about 3 years

Additionally, there are further issues:

- there is a long transport distance between LNG production facilities and site, and this raises the LNG cost at site significantly,
- acquiring social license and passing an environmental assessment is expected to be more challenging than for other options, and
- life-cycle GhG assessments indicate reductions from LNG may be marginal due to the long-haul distances, lower energy density, and as regulatory trends look to include upstream emissions in LNG emissions factors.

An example of the LNG supply chain to Inuvik follows:

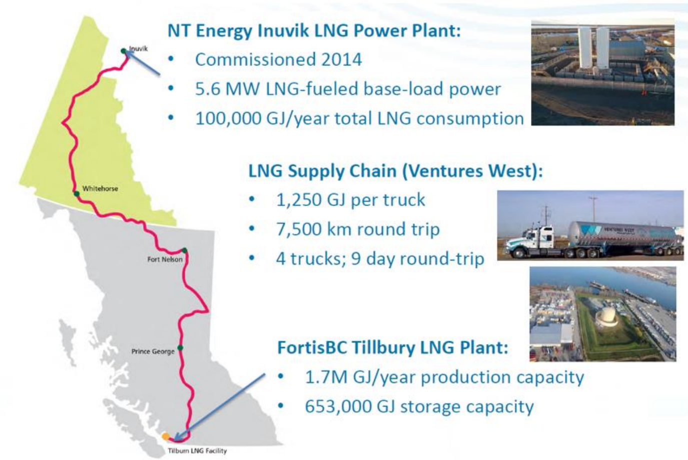


Figure 19 Inuvik LNG Supply Chain (NT Energy)

A case study from Yukon Energy on lessons learned on LNG social license follows:

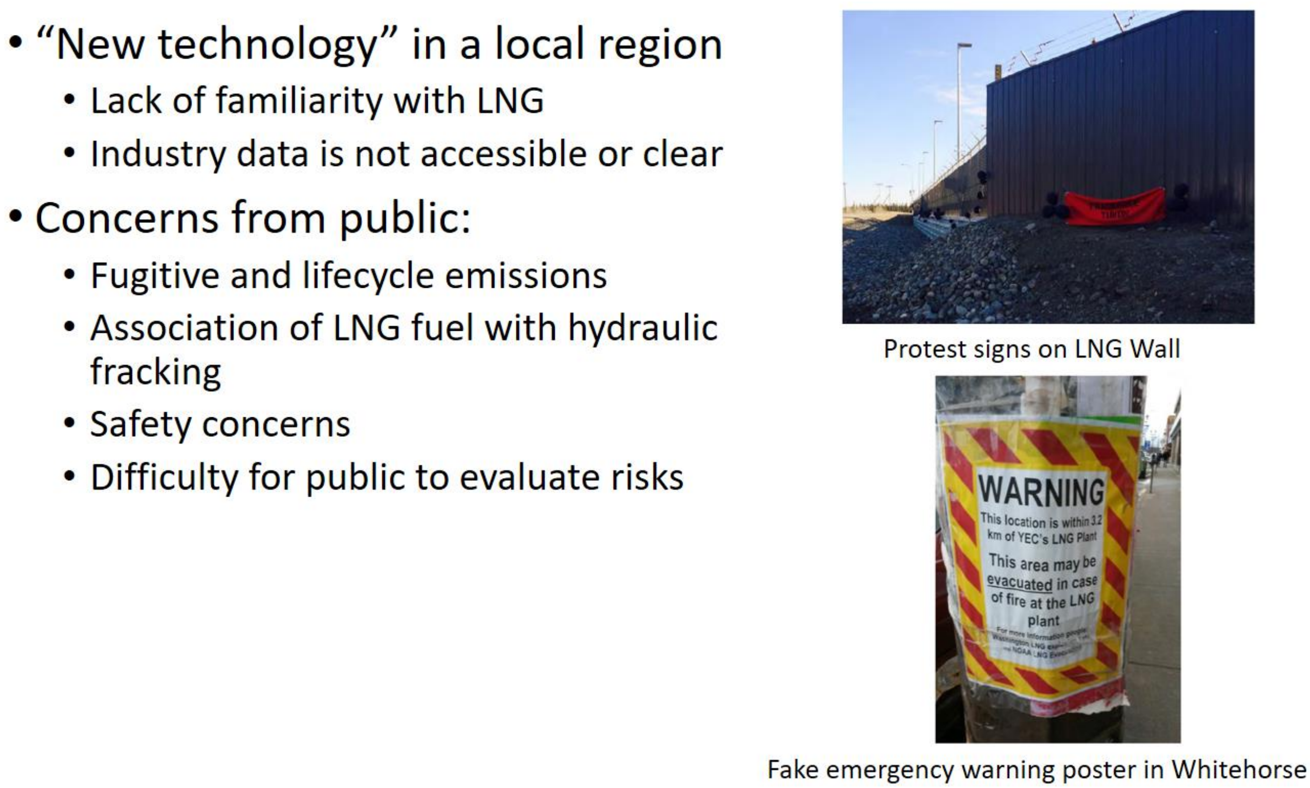


Figure 20: Social License Lessons Learned on LNG from Yukon Energy

Based on the issues presented above, it is not recommended to continue with a review of LNG use for power generation at the Ekati mine.

5.7 Hydroelectric

Hydroelectric power is prevalent in the NWT, and there is reasonably good hydroelectric potential there.

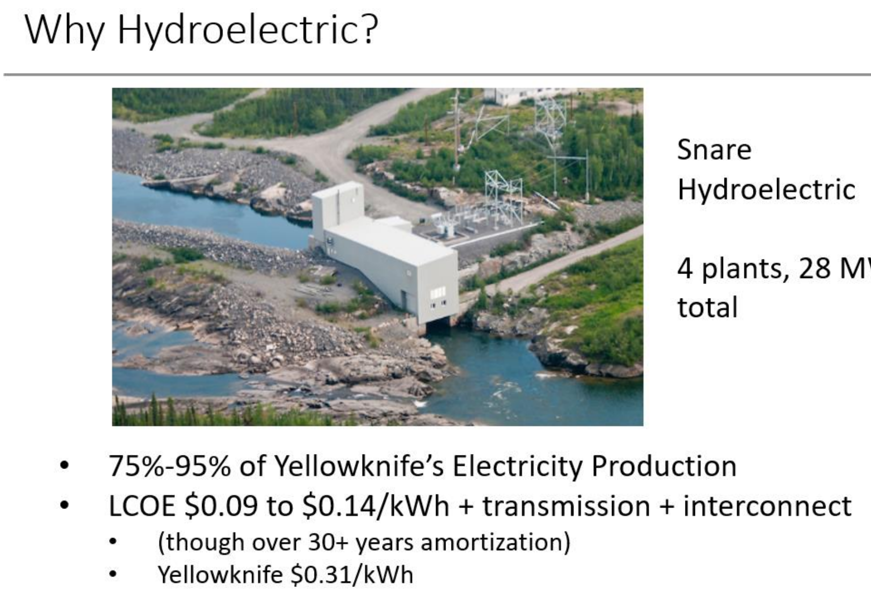


Figure 21 Hydroelectric in the NWT Example. LCOE = Levelized cost of electricity.

The summary assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Hydroelectric (1-10 MW), Small Hydro or Run-of-River	**Low** No good hydro resources near Ekati. Long build time.	**Low** Longer payback than life of mine	**Medium** +Low GHGs -Some changes to ecosystem can affect fish	**Medium** +Renewable; self sufficient -Impact on waterway & fish	Not assessed, but a good site is ~$0.30/kWh over 20-30 years	Not assessed, but a good site is ~$10k to 30k/kW with large up front costs

Further considerations were not done as this option is straightforward to rule out.

The main issues with hydroelectric power for the Ekati mine are:

- minimal good hydro resources close to the mine (either a river or a grid powerline). Transmission lines are very expensive at $350,000 to $600,000 per km in less remote settings, and $1,000,000 to $2,000,000 per km given the logistical challenges and high cost of construction at Ekati,
- transmission lines often have permitting challenges,
- medium sized hydroelectric power systems (such as Snare near Yellowknife) have a development time on the order of 10 years. A new hydroelectric facility would not fit well with

the planned life of mine for Ekati, even assuming the Jay project is successfully permitted and developed,

- smaller run-of-river hydroelectric facilities are difficult to make work in the North, because there is significantly less power from these systems in the winter months, when the power is needed the most, and
- compared to community-based installations, which can have a design life of decades, mines have finite resource base and therefore a limited life, reducing the guaranteed lifespan of the system and further increasing the levelized cost of electricity.

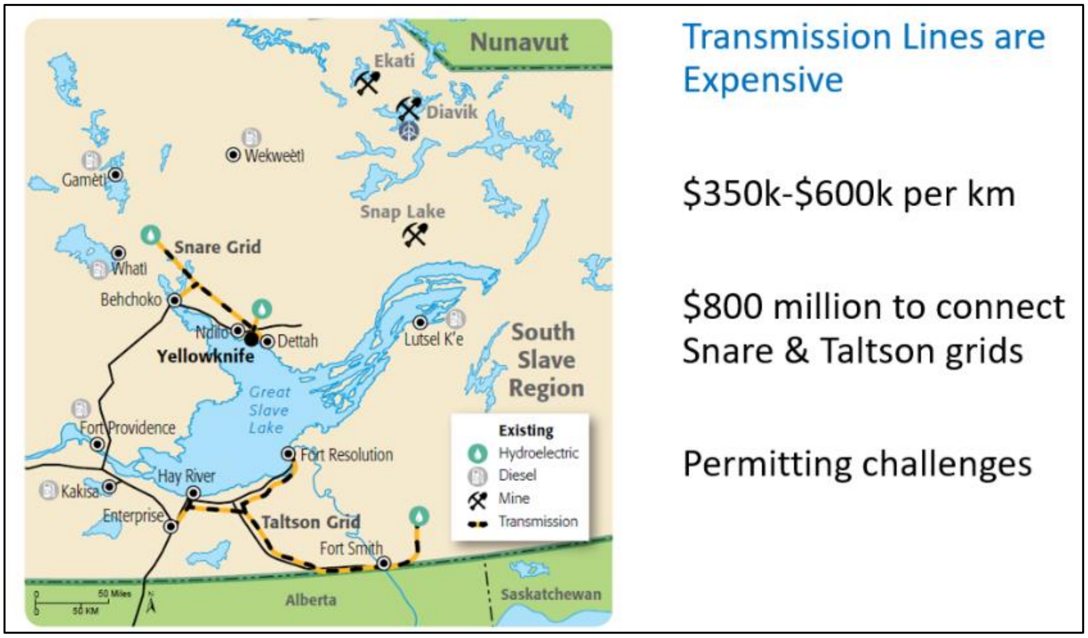


Figure 22 Lessons learned hydroelectric in NWT

Run-of-river assessment:

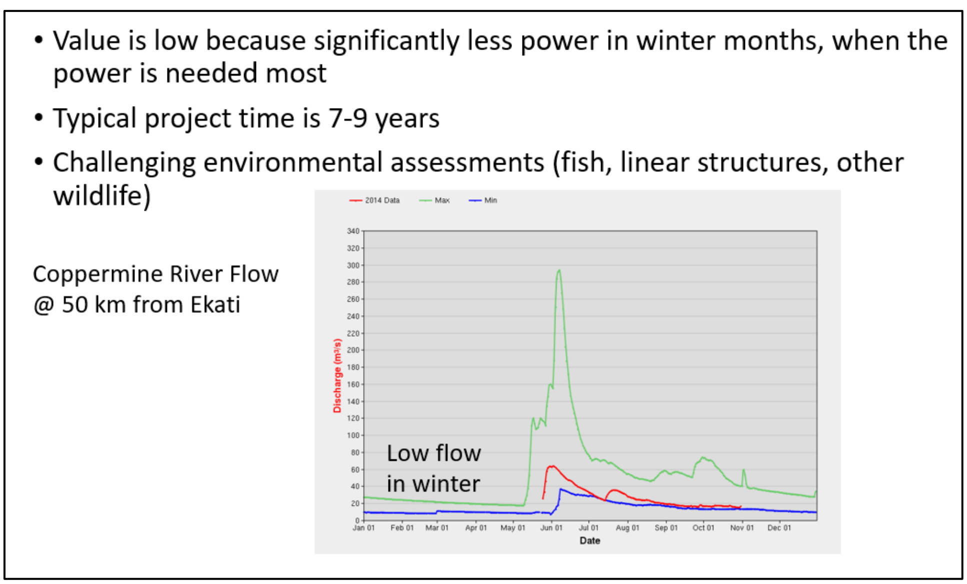


Figure 23 Run-of-river in the North

Based on the issues presented above, it is not recommended to continue with a review of hydroelectric power for Ekati mine.

5.8 Geothermal

There is good experience in some regions with geothermal energy and electric power. For example, in Iceland, 25% of their electricity production is from geothermal with a levelized cost of electricity of $0.05/kWh.

Figure 24 Hellisheidi Geothermal 303 MWe Power Station, Iceland

The Mackenzie basin has some good geothermal potential, however there are no viable geothermal potentials in and around the Ekati Mine.

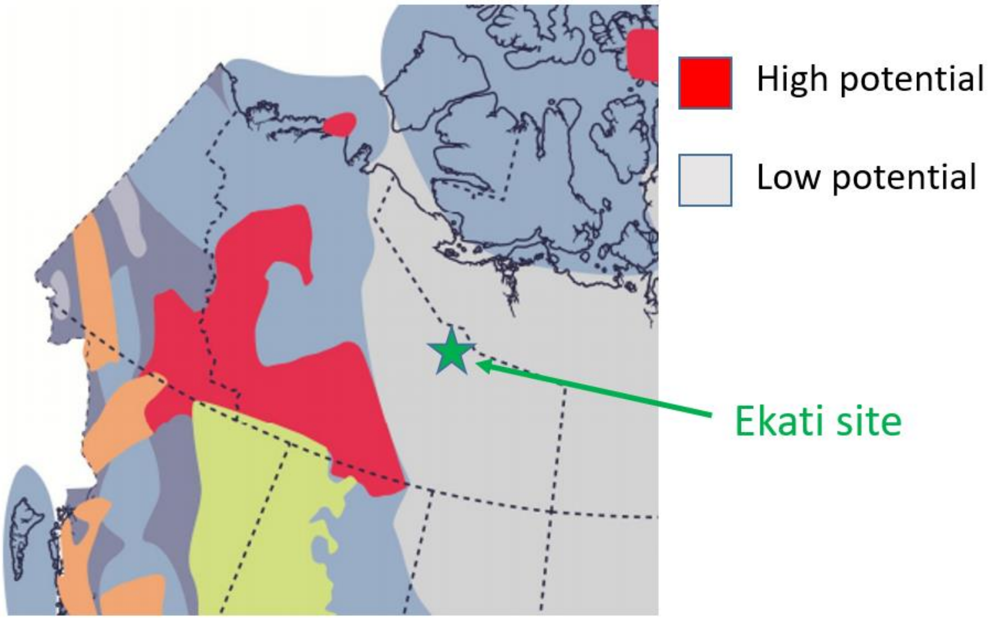


Figure 25 Geothermal Potential NWT (Paper from GNWT)

The summary assessment follows:

	Summary					
Option	**Technical Viability**	**Economic Benefits**	**Environmental Performance**	**Social Benefits**	**Cost of Energy $/kWh or $/litre**	**Installation Cost $/kW**
Diesel	**High** Universally viable	**Nil** Status quo	**Low** GHG Emissions, air quality, chance of spill	**Low** Imported fuel; local health	Baseline	$3000/kW if new, but existing diesels ok
Geothermal electricity	**Low** No hot spots near Ekati. Long build time.	**Low** Longer payback than life of mine	**Medium** Low GHGs, but land use, water use, emissions	**High** Renewable; self sufficient	Not assessed, but a good site is ~$0.10/kWh to $0.25/kWh over 20-30 years	Not assessed, but a good site is ~$10,000/kW with large up front costs

Further considerations were not investigated as this option is straightforward to rule out.

The main issues for geothermal energy at the Ekati mine are:

- no viable geothermal resources close to the mine site,
- geothermal systems typically have a long development time of about 10 years. A new geothermal facility would not fit well with the planned life of mine for the Jay Project, and
- there is still significant risk for geothermal systems:
    - geothermal is not a priority area for the Canadian or NWT Governments,
    - drilling costs and success are uncertain, and
    - the technology is somewhat new to Canada and the NWT.

Based on the issues presented above, it is not recommended to continue with a review of geothermal power for the Ekati mine.

6 SUMMARY

The summary results are:

6.1 Wind

The variable nature of wind makes it challenging to integrate wind into isolated microgrids, add to this challenging weather conditions and it is not surprising that wind applications in Canada's North and Alaska have seen mixed results over the past 15 years. Altogether, at least two mining operations have successfully applied wind energy and a further two mining operations and eight communities are presently successfully using or monitoring wind resources for future wind power installations.

One of those mining wind projects, the Diavik Diamond Mine, jointly owned by Rio Tinto and Dominion Diamond Corporation, provides a relevant example of the successful application of wind turbines as it is both similar in size and close in proximity to the Ekati mine. Diavik's wind project has been in operation over the past 4 years during which time the system has demonstrated good performance, reliability, and good project economics.

The original payback for the Diavik 9.2 MW wind project was estimated to be 8 years; now, after 4 years of successful operation, the project is forecast to have a payback of 6-7 years. Assuming a timeline of 5 years from the completion of this concept study to the beginning of operations, plus a payback period of 7 years, Dominion's experience at Diavik indicates that a similar investment at the Ekati mine could break even by 2029, and return a marginal profit thereafter. While 2029 is beyond the mine life of Ekati without Jay, assuming Jay can be successfully permitted and economically developed,the Ekati mine is forecast to have a mine life of 2034. This indicates that a positive return may be possible for a new wind installation. There is also some potential to reduce the timeline for a wind farm project by 1-2 years, by reducing the amount of wind data prior to procurement, though this entails additional risk.

The other opportunity available regionally would be to connect the Ekati and Diavik grids, enabling the Diavik wind farm to continue to supply power after the currently projected closure of the Diavik operation in 2023. The existing grids are only 10 km apart. Re-use of the existing wind infrastructure at Diavik would likely have superior economics compared to a new installation. Technical challenges in construction of a transmission line and integration of the grids, as well as commercial challenges in reaching an agreement between the various stakeholders, would need to be addressed.

Overall, it is recommended to advance into more detailed economic and technical studies of opportunities for both new and existing wind power generation.

6.2 Small scale solar for off-grid applications

Mines often have numerous ancillary operations that require intermittent or very low power requirements, for loads such as instrumentation devices, low footprint outbuildings, lighting, and small pumping loads. These smaller off-grid loads often require a continuously operating diesel generator. Using a solar array combined with battery storage presents an opportunity to power these smaller, more intermittent loads, eliminating the requirement of portable diesel gensets.

Solar installations in the medium size range, about 50-200 kW, may be advantageous in a number of applications. For example, they are potentially attractive in pumping situations where smaller pumping demands are required during spring runoff (highest solar radiation) for multiple years. At the Ekati mine, the near-term dewatering needs are in the 1+ MW level, but pit filling needs may be much smaller (can only take a small flow from the lake) and could be a potential opportunity. This opportunity may make sense in the future, as reclamation planning continues to advance, the de-watering/pit filling needs become better known, and solar installations continue to drop in price. If these applications can be sufficiently advanced, they could substantially reduce reclamation costs, and potentially lower reclamation security requirements.

In addition, the wide variety of Ekati outbuildings, each of which have different peak load, seasonality, reliability, and accessibility requirements, should be studied to determine which are most suited to small-scale off-grid solar installations.

Overall, it is recommended to advance into more detailed economic and technical studies of opportunities for small-scale solar for off-grid applications.

6.3 Biodiesel

Biodiesel has been piloted successfully in select equipment at the Ekati mine, through the onsite mixture of 100% biodiesel (B100) with regular diesel to make a B10 or B20 for use in mobile equipment during the summer months. Further usage expansion up to 5 million litres per year is technically practical, although some issues with regular usage exist, including:

- biodiesel is approximately 25% more expensive than regular diesel,
- blends of biodiesel above B5 present cold weather operating challenges including gelling and filter plugging; a standardized “winter blend” supply would be helpful, and
- there is a limited supply chain to the North.

Biodiesel is much more prevalent in the US because of their consumption mandates and incentive systems. In Canada, even with a future carbon tax of $50/tonne, biodiesel would still be more costly than diesel as the carbon tax only makes a difference of $0.10/litre. Long-term increases to carbon pricing beyond $50/tonne, potentially combined reductions in certain fossil fuel subsidies, could narrow the cost difference.

Larger scale use of biodiesel should be considered in future when it achieves price parity either from industry economies of scale, regulatory support, or renewable incentive programs. Additionally, a robust Northern supply chain is also required.

6.4 Wood pellet boilers

Wood pellet boilers for space heating are prevalent in Yellowknife both in residential and commercial buildings, allowing for approximately a 30-50% reduction in heating bills over heating oil. The Ekati mine uses a significant amount of diesel for space heating.

The main issue with wood pellets for the Ekati mine are:

- wood pellets have only 1/3 the energy density of diesel, requiring three times more trucks for the same amount of energy therefore increasing the number of trucks over the ice road which would be difficult given the current ice road constraints,
- the additional trucking of wood pellets over the ice road adds significantly to the overall fuel cost, and largely consumes the savings between wood pellets and diesel, and
- replacing one of the main boilers in the Ekati camp would require a very large wood pellet system (i.e. 7 MW), which would be expensive and require a large amount of wood pellet storage. It would be difficult to make an overall business case for this concept.

The Jay Project includes a Jay construction camp, where adding a wood pellet boiler could be technically feasible. However, electrical heating is the standard specification of most construction camps, due to the reduced installation labour, which allows for quicker and lower cost assembly. This is especially true for the many camps currently available on the used market due to the downturn in commodity prices. Requiring boiler-fired heating for a construction camp would significantly limit the procurement choices for the structure.

A modest amount of wood pellets and a smaller boiler, ~1 MW, could be a feasible option for future consideration, especially if the current winter road were replaced with an all-season access road, reducing transportation costs and storage requirements.

6.5 Solar PV grid-connected 100 kW class

Solar PV (photovoltaic) is currently being used in more than 20 installations in the NWT, up to the 100 kW class, including at Colville Lake, Lutsel K'e, and Fort Simpson. The Ekati mine's microgrid supplies 16 MW, on average, hence it has the capacity to add on the order of 100 kW solar generation to the grid without complex controls or energy storage, as the flexibility in the diesel powerhouse can handle the intermittence of this amount of solar generation. Much larger systems (i.e. 500 kW+) would be capital cost prohibitive. Solar PV can help reduce diesel consumption, is relatively easy to maintain and offers a consistent, "free" fuel.

The main issues with Solar PV for the Ekati mine are:

- the capital cost of Solar PV in the North is higher than in the South because of the more extreme environment and higher transportation and installation costs,
- the solar power generation (PV potential) in the North is good around the spring equinox at about 1,000 kWh/kW per year, however this is still lower than in the South (i.e. California) where solar PV is approximately 2,500 kWh/kW per year,
- the estimated levelized cost of electricity for solar PV is about three times higher than electricity from diesel, and
- compared to community-based installations, which can have a design life of decades, mines have a finite resource base and therefore a limited life, reducing the guaranteed lifespan of the system and further increasing the levelized cost of electricity.

Overall, the economics and resulting high levelized cost of electricity, together with the low penetration attainable for this type of installation rule out the application of grid-connected solar PV for the Ekati mine given current costs. Further assessment of this option is, therefore, not recommended at this time. Solar technology does continue to be an area of rapid innovation, and this conclusion should be revisited if there are substantial and demonstrated economic improvements by others in comparable conditions.

6.6 LNG

LNG (liquefied natural gas) has been used successfully in Inuvik and at the Stornoway Renard Mine in Quebec as a lower cost option than diesel. However, both of those sites have all-season roads, and thus can receive regular (daily) deliveries, which allows them to utilize a small LNG storage system on-site.

LNG could be used at the Ekati mine, in the powerhouse, using bi-fuel kits on the diesel generators, and in haul trucks.

The main issue with LNG at the Ekati mine is that there is currently no all-season road to site from the South, and this necessitates a large amount of storage at each end of the ice road (at the Ekati mine and in Yellowknife). For a system that would provide 11% of the Ekati mine's diesel consumption, LNG infrastructure in excess of $100 million would be required.

Additionally, there are further issues:

- there is a long transport distance between LNG production facilities and site, and this raises the LNG cost at site significantly,
- acquiring social license and passing an environmental assessment is expected to be more challenging than for other options, and
- life-cycle GhG assessments indicate reductions from LNG may be marginal due to the long-haul distances, lower energy density, and as regulatory trends look to include upstream emissions in LNG emissions factors.

Based on the issues presented above, it is not recommended to continue with a review of LNG use for power generation at the Ekati mine unless all-season road access advances.

6.7 Hydroelectric

Hydroelectric power is prevalent in the NWT, and there is reasonably good hydroelectric potential there.

The main issues with hydroelectric power for the Ekati mine are:

- minimal good hydro resources close to the mine (either a river or a grid powerline). Transmission lines are very expensive at $350,000 to $600,000 per km in less remote settings, and $1,000,000 to $2,000,000 per km given the logistical challenges and high cost of construction at Ekati,
- medium sized hydroelectric power systems (such as Snare near Yellowknife) have a development time on the order of 10 years. A new hydroelectric facility would not fit well with the planned life of mine for Ekati, even assuming the Jay project is successfully permitted and developed,
- smaller run-of-river hydroelectric facilities are difficult to make work in the North, because there is significantly less power from these systems in the winter months, when the power is needed the most, and
- compared to community-based installations, which can have a design life of decades, mines have finite resource base and therefore a limited life, reducing the guaranteed lifespan of the system and further increasing the levelized cost of electricity.

Based on the issues presented above, it is not recommended to continue with a review of hydroelectric power for the Ekati mine.

6.8 Geothermal

There is good experience in some regions with geothermal energy and electric power.

However, the main issues for geothermal energy at the Ekati mine are:

- no viable geothermal resources close to the mine site,
- geothermal systems typically have a long development time of about 10 years. A new geothermal facility would not fit well with the planned life of mine for the Jay Project, and
- there is still significant risk for geothermal systems:
    - geothermal is not a priority area for the Canadian or NWT Governments,
    - drilling costs and success are uncertain, and
    - the technology is somewhat new to Canada and the NWT.

Based on the issues presented above, it is not recommended to continue with a review of geothermal power for Ekati mine.

6.9 Summary results

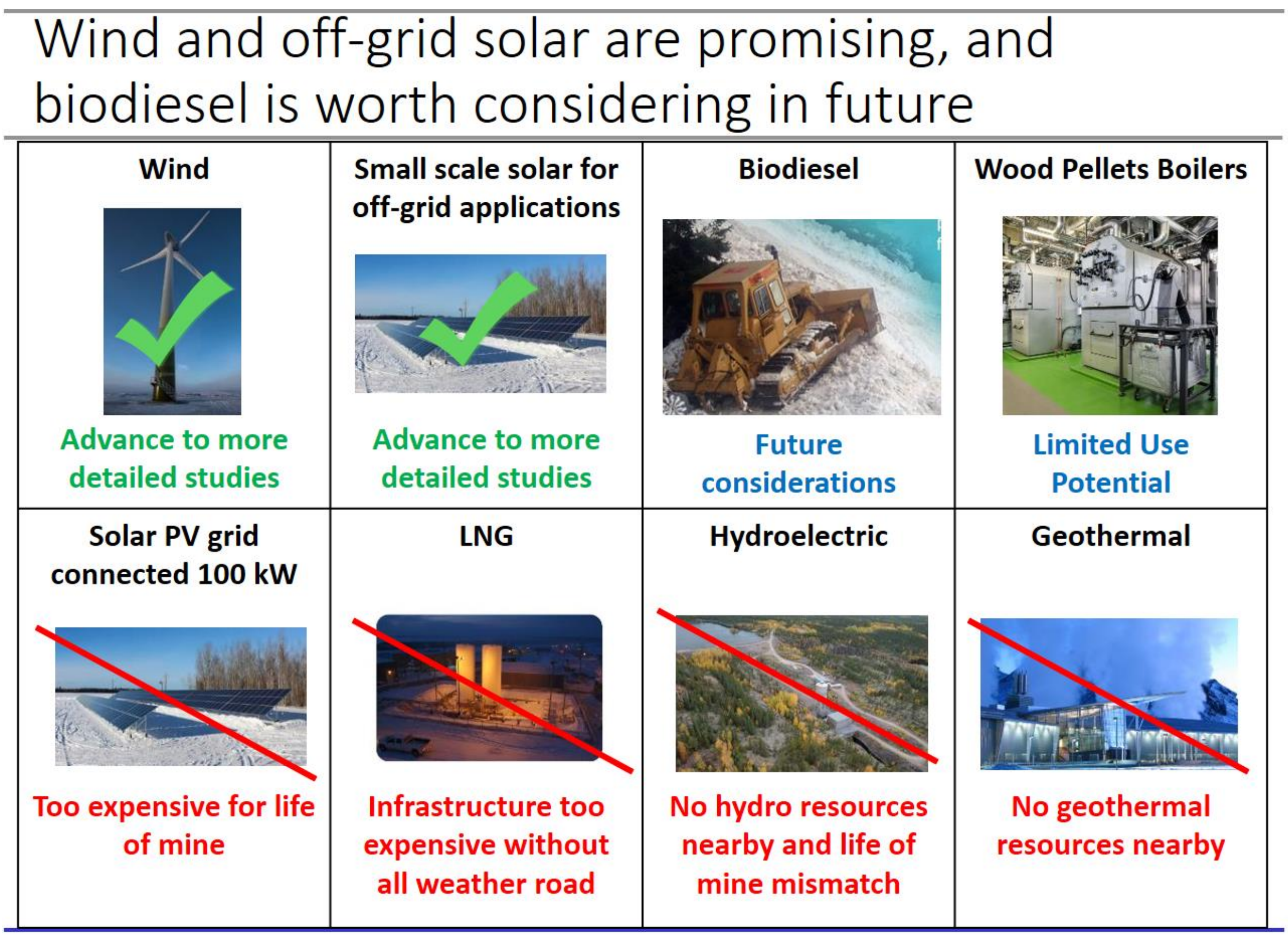


Figure 26 Alternative Energy Summary Assessment